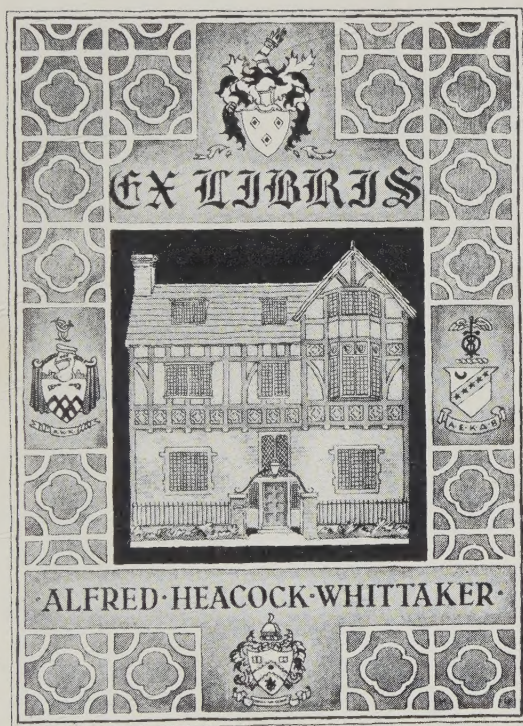


John S. Currier, m. 2,



ALFRED · HEACOCK · WHITTAKER ·

EXPOSURES OF LONG BONES
AND OTHER SURGICAL METHODS

EXPOSURES OF LONG BONES AND OTHER SURGICAL METHODS

BY

ARNOLD K. HENRY, M.B., B.CH, Univ. Dublin, F.R.C.S.I.,

Chevalier, Legion d'Honneur ;

Professor of Clinical Surgery, Royal School of Medicine, Cairo ;

Director of the Surgical Unit, Kasr el Aini Hospital.

FOREWORD BY

SIR W. I. DE C. WHEELER (Dublin)

NEW YORK:
WILLIAM WOOD AND COMPANY
MDCCCXXVII

PRINTED IN ENGLAND BY
JOHN WRIGHT AND SONS LTD.,
BRISTOL

TO
A. A. McC., *Surgeon*
AND
E. J. R. E., *Anatomist*



Digitized by the Internet Archive
in 2025

PREFACE

THE various papers which form this volume have a unity, if not of subject, at least of time and origin. They were written between 1920 and 1926, and they are inseparably linked with the operation theatre of the Richmond Hospital, Dublin, and with the dissecting-room of the Royal College of Surgeons in Ireland. All but two of them arose out of problems, difficulties, or disaster in the course of my ordinary clinical work during that period. Thus a case of gunshot fracture of the femur which died from the added hæmorrhage of a lateral approach led me to seek a less bloody method.

The section describing exposures of bone, however, requires fewer apologies than the rest, for the treatment of the subject in text-books has been too slight to have much practical value.

With regard to the papers dealing with less diurnal subjects, I am encouraged, by a valued letter from Sir Clifford Allbutt, to include a dorsal approach to the stellate ganglion, which arose out of Jonnesco's bold and successful raid into cardiology. Investigation of the ganglion led me to chance on an exposure of the first part of the left subclavian artery from behind, an operation which might well seem too exceptional to deserve description. But it is certain, since the world is wide, that when surgical means appear occasions arise for their use, and recently Mr. W. Hailes, of Melbourne, has most kindly sent me an account of a successful ligation of the left subclavian performed from the description which is reprinted here.

The exposure of the *second* part of the vertebral artery was devised because it was decided to ligate it in a case of innominate aneurysm, and though, as the reader will see, this

was not done, the description is given in the hope of providing a key to a surgical hinterland.

It is impossible to write on exposures of these kinds after MM. Fiolle and Delmas without being sensible of the inspiration of their book, which in its tiny bulk contains the whole spirit of the art. None the less it is my belief that volumes on operative surgery are too often written by those who are so experienced that much of their technique is subconscious and therefore inexpressed, and if I have given weight to details which some may welcome and others scorn, it is because my own difficulties are not yet sufficiently forgotten.

I have tried wherever relevant to summarize the steps of operations in legends which accompany the figures, and I have put these legends in the form of practical directions to the surgeon.

My thanks are due to the *British Journal of Surgery* and to the *Irish Journal of Medical Science* for permission to use some of the papers which have appeared in their pages. A few of the simpler figures are my own, but for the rest I am indebted to Mr. Matthew Barry for his patience, skill, and comprehension.

ARNOLD K. HENRY.

Cairo, 1927.

CONTENTS

	PAGE
FOREWORD BY SIR W. I. DE COURCY WHEELER - - -	xi

SECTION I

EXPOSURES OF LONG BONES

EXPOSURE OF THE HUMERUS	-	-	-	-	-	3
EXPOSURE OF THE RADIUS	-	-	-	-	-	9
EXPOSURES OF THE FEMUR	-	-	-	-	-	13
THE FEMORAL SHAFT	-	-	-	-	-	13
THE POPLITEAL FACE—Internal (or Medial) Exposure	-	-	-	-	-	18
External (or Lateral) Exposure	-	-	-	-	-	22
EXPOSURE OF THE FIBULA	-	-	-	-	-	26

SECTION II

OTHER SURGICAL METHODS

EXPOSURE OF THE PLANTAR STRUCTURES	-	-	-	33
A METHOD OF LIGATING THE SECOND STAGE OF THE VERTEBRAL ARTERY	-	-	-	37
A METHOD OF LIGATING THE FIRST STAGE OF THE LEFT SUBCLAVIAN ARTERY FROM BEHIND	-	-	-	45
A CUP-AND-BALL ANEURYSM NEEDLE FOR DEEP LIGATIONS	-	-	-	55
A NEW METHOD OF RESECTING THE LEFT CERVICODORSAL GANGLION OF THE SYMPATHETIC	-	-	-	58
PITUITARY SURGERY BY A NEW METHOD	-	-	-	69

FOREWORD

By SIR W. I. DE C. WHEELER, DUBLIN

THERE are many occasions when surgeons find it desirable to ponder over an operation prior to its performance. In these moments of meditation, inspiration is sought from the bookshelves, not because special difficulties are anticipated or novel procedures are in contemplation, but because the direct path, over which pioneers have already travelled, is found carefully charted.

Books which view operations from an original angle, and books which avoid the fatal jungle of empiricism, will always have a prominent place in the reference library of the scientific surgeon. The author has provided a valuable contribution to such a library.

Few days pass in the theatre of a general hospital without an operation necessitating the exposure of one or other of the long bones. The lines of incision for such exposures have heretofore received but scant attention; those which Professor Henry advocates in the opening chapters are lines of safety, of simplicity, and of speed. Exactitude is the outstanding feature of his recommendations.

More difficult problems are discussed in the second section of the book. Here again the reader will appreciate and benefit by the spirit of investigation and original thought. Exposure of the plantar structures is described. A method for ligation of the second stage of the vertebral artery is suggested, and the details of an approach from behind for ligation of the first stage of the left subclavian artery are admirably given.

The surgery of the sympathetic nervous system has received wide attention during the last decade. Operations in this sphere require careful preliminary study. Professor Henry's new method of resecting the left cervicodorsal ganglion will stimulate interest and thought.

The book concludes with a discussion on the surgery of the pituitary gland, and once again the personality of the author becomes prominent: he appears to visualize the difficulties of those who are called upon to perform such operations only at rare intervals.

The saying that all good things which exist are the fruits of originality applies more especially to surgery. Professor Henry's book not only is full of good things, but overflows with practical information which cannot be obtained from any other source.

EXPOSURES OF LONG BONES
AND OTHER SURGICAL METHODS

Section I

EXPOSURES OF LONG BONES

EXPOSURE OF THE HUMERUS*

A SURGICAL exposure may avoid injury to structures by defining them or by avoiding them completely; the method in question is a compromise. It lays bare the front of the humerus from end

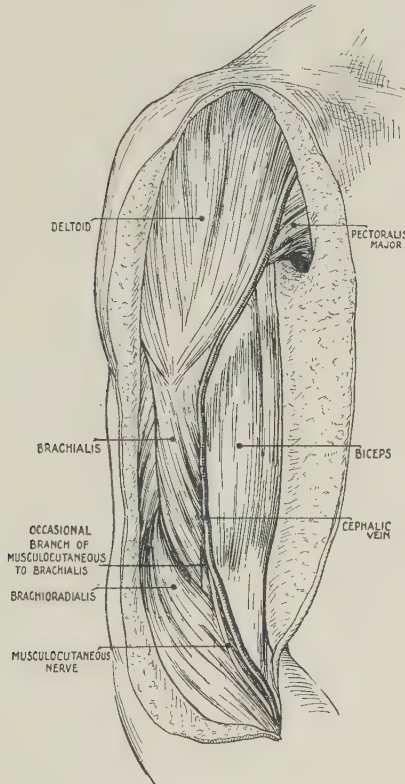


FIG. 1.—Dissection of the right arm seen from the outer side. The uncovered outer fourth of the brachialis appears between the biceps and brachioradialis, and extends behind the pointed deltoid insertion. It can be used as a buffer to protect the musculospiral nerve. The occasional small branch of the musculocutaneous to the brachialis muscle is shown.

to end, leaving the musculospiral nerve protected and concealed; if further exposure is required, the nerve is directly available.

* *Brit. Jour. Surg.*, 1924, xii, 84.

ANATOMY.

The upper portion of the humerus is concealed by the *deltoid* (*Fig. 1*), which arises in front from the edge of the clavicle's lesser curve, forming a thick unyielding curtain which gives, when pulled aside, a grudging revelation of the shoulder-joint. This is often the last successful thing it does. The lower half of the bone is clothed in front by the longitudinal fibres of the *brachialis muscle*. The outer fourth of the brachialis is not covered by the biceps (*Fig. 2*). The shaft can be exposed by splitting this

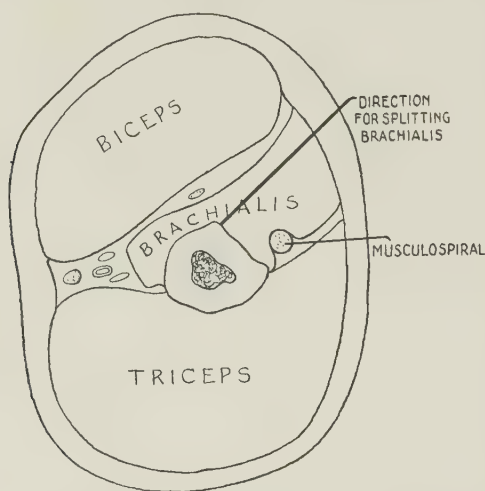


FIG. 2.—Cross-section through mid-third of arm, showing the outer fourth of the brachialis left uncovered by the biceps belly. This part of the brachialis is split in the direction of the pointer to expose the humerus. The musculospiral is safe.

uncovered outer fourth. The proximal part of the brachialis origin forms a hollow v into which the solid v of the deltoid fits (*Fig. 3*).

The *musculospiral nerve* (radial, B.N.A.) lies behind the posterior limb of the brachialis v. and when this is detached the nerve is found one finger-breadth distal to the deltoid tip. The inner head of the triceps separates part of the nerve from the back of the humerus.

The distal half of the retrohumeral stage of the musculospiral is the only part of the nerve in direct normal contact with bone. The *cutaneous branch of the musculocutaneous* curves forward at the outer edge of the biceps just where the belly joins the tendon of insertion. One of its filaments is cut in the upper third of the forearm. An inconstant filament from the musculocutaneous described by Luschka and Henle, but neglected by many more recent authorities, supplies the outer fourth of the brachialis muscle in its distal part. I have found it three times in ten arms. The other branches of the brachialis are under cover of the inner portion of the upper half of the biceps belly.

The *cephalic vein* follows the outer border of the biceps and the inner border of the deltoid, piercing the deep fascia in the lower third of the arm. It receives two or more tributaries on the outer side: these must be divided. The humeral branch of the thoracic axis artery accompanies the vein in the groove between the deltoid and the pectoralis major, and gives branches to both muscles.

THE OPERATION.

Position.—The patient lies with the limb close to his side and supported by the operating-table. The elbow is extended, and, when required, is flexed by an assistant.

Incision.—For exposure of the *shaft*, the skin incision (BC, *Fig. 4*) follows the cephalic vein from the coracoid tip to the bend of the elbow, and is continued into the forearm in

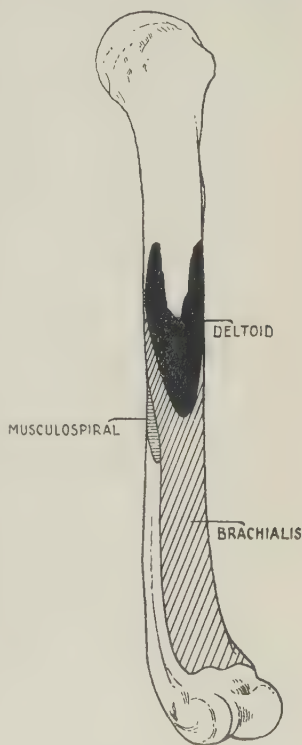


FIG. 3.—Anterolateral view of the humerus, showing how the solid V of the deltoid insertion fits into the hollow V of the brachialis. The musculospiral lies behind the outer limb of the brachialis V.

the mid-line of its upper third. The vein is exposed, and the outer edge of the biceps belly defined by dividing the deep fascia along its outer side.

Partial exposure of the bone may be obtained by shorter incisions, but these should never be short. Thus, to expose the distal part of the shaft, continue the incision well into the upper third of the forearm, dividing the deep fascia with blunt-nosed scissors to avoid injuring the radial artery and the cutaneous terminal (radial) branch of the musculospiral nerve: this division of the fascia allows wide retraction of the muscles.

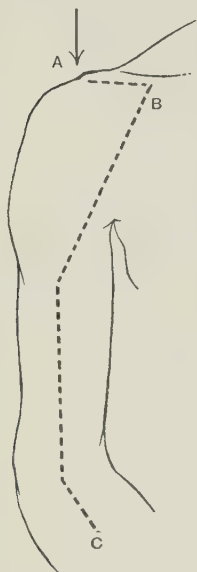


FIG. 4.—For complete exposure cut through skin and deep fascia along the dotted line ABC. (The arrow marks the 'step-down' at the acromioclavicular joint.) Expose (1) the deltoid attachment to the outer third of the clavicle, (2) the inner edge of the deltoid, and (3) the outer edge of the biceps. Continue the division of deep fascia throughout the upper third of the forearm. Split the brachialis as shown in Fig. 2.

Cut down on the humerus, first along the deltoid border; then divide the exposed outer fourth of the brachialis muscle longitudinally, a finger-breadth from the outer edge of the biceps. This cut is directed *inwards* to reach the humerus in the middle line (Fig. 2); it avoids Luschka's filament to the brachialis, and splits the muscle where its fibres are longitudinal. The outer strip of the brachialis, thus separated, forms a buffer which protects the musculospiral nerve from the rugine. The nerve is not seen if the front only of the humeral shaft is exposed, and the back too can be cleared safely while the nerve is concealed; but should the surgeon wish, the musculospiral can be found one finger-breadth distal to the deltoid insertion by further mobilizing the outer portion of the brachialis and

retracting it outwards and back; the nerve then appears behind the upper fibres of the muscle, and the pull on the brachialis strip removes it just sufficiently from contact with the shaft to allow the rugine safe access to the bone. The nerve is most

lax when the arm is adducted and the elbow flexed through 80° ; it is then most easily protected.

The incision may be carried through the brachialis to within two finger-breadths of the level of the epicondyles, without



FIG. 5.—Separate the split brachialis from the bone; retract the inner and outer portions of the muscle. Relax it by flexing the elbow. The lower half of the bone is now exposed. In the figure the elbow-joint is opened and the coronoid process is seen. If exploration of the elbow-joint is not required, check the cut in the brachialis two finger-breadths above the epicondyles.

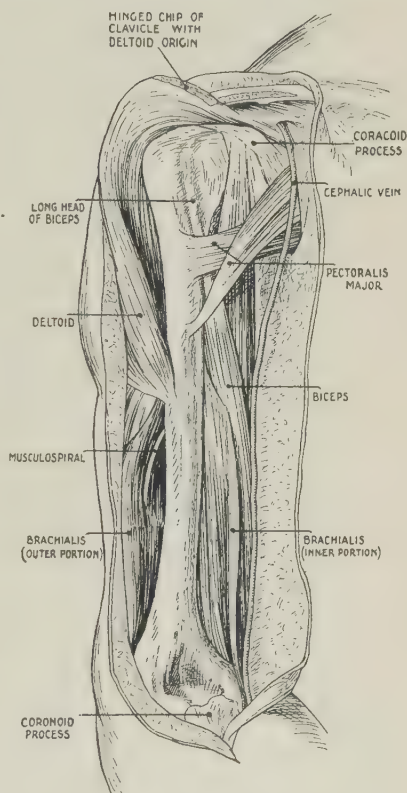


FIG. 6.—Complete the exposure of the humerus by turning the deltoid outwards on a hinged chip cut from the clavicle (see also Fig. 7). The musculo-spiral can be found, if required, by detaching the part of the brachialis which extends behind the deltoid tip.

entering the elbow-joint. The bone seen through the split brachialis appears to lie at a considerable depth when the joint is extended. Flexion of the elbow to a right angle transforms

this appearance, relaxing the muscle and leaving the bone widely accessible in a shallow wound (*Fig. 5*).

The front of the humeral shaft is now exposed in its entire length, completely in its lower half, but above, the deltoid yields insufficiently to retraction and gives a mere glimpse of the bone.

The Shoulder-joint.—This, with the upper part of the shaft and the tuberosities, can be exposed by continuing the skin incision outwards on the upper surface of the clavicle to the acromioclavicular joint, easily found by running the finger out along the clavicle; the finger takes, as it were, a step down at the joint (*Fig. 4*). Expose the deltoid origin by reflecting the

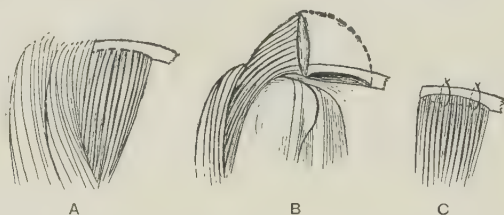


FIG. 7.—Cut the hinged chip from the clavicle along the line shown in A. B, Turn the deltoid out upon the hinged chip. C, Reconstitute the deltoid origin with two sutures which tie the chip back into place.

skin. Divide the fascia and periosteum on the upper face of the outer third of the clavicle. With a chisel, detach the edge of bone which gives origin to the deltoid, as far as the acromioclavicular joint. The deltoid can then be turned outwards on a hinged piece of bone, like a sail on a spar (*Figs. 6, 7*).

When the shoulder-joint has been dealt with, sutures passed through the muscle and round the clavicle lash the spar back into place, and reconstitute the deltoid origin (*Fig. 7 c*).

The Elbow-joint.—This joint can be opened by extending the incision through the brachialis. The tip of the coronoid process and the trochlea are at once visible; the head of the radius and the capitulum appear with adequate retraction (*Fig. 5*).

When the operation on the bone is finished, extension of the elbow, before suturing the fascia, closes of itself the wide wound in the muscle.

COMPLETE EXPOSURE OF THE RADIUS *

THE entire length of the radius is most easily exposed through an anterolateral incision.

ANATOMY.

Three long muscles flank the bone upon its lateral border—the brachioradialis, miscalled the supinator longus, and the long and short extensors of the wrist. They can be retracted outwards when they have been relaxed by bending the elbow. These three muscles have origins which are proximal to the elbow-joint, and in order to mobilize them fully the incision must extend proximal to the elbow. Further, this lateral group of three is strapped to the lower fourth of the radial shaft by two short muscles, which form an oblique prominence when the hand is prone. When the long muscles are raised from the bone, these two short muscles are raised with them.

The *pronator teres*, inserted at the middle of the radial shaft upon its outer face, will then be exposed, and full pronation of the hand will reveal an expanse of bone in the lower half of the shaft.

The *supinator muscle* grasps the upper third of the shaft, and the *posterior interosseous nerve* (deep branch of the radial, B.N.A.) penetrates the anterolateral face of the supinator, and lies between two layers of the muscle: the deep layer separates the nerve from the



FIG. 8.—Anatomical relationships at the upper part of the radius. The white crescent between the two black insertions represents the bicipital bursa and shows how it lies in a bay formed by the supinator edge. The surgeon is guided to the bursa by the outer face of the biceps tendon (see Fig. 11).

* *Brit. Jour. Surg.*, 1926, xiii, p. 506.

bone. The supinator attachment to the radius skirts the edge of the bicipital tubercle, which is covered in front by a bursa (*Fig. 8*).

The Deep Guide.—The edge of the supinator is obscured by the loose connective tissue that surrounds the recurrent radial vessels, but it can be reached with precision by following the outer face of the biceps tendon. The outer face of the tendon leads the surgeon to the bursa: the knife cuts down through this to the tuberosity, and at once affords the rugine a point of direct contact with bone (*see Fig. 11*). It is then easy, starting at the edge of the muscle, to begin detaching the grasp of the supinator from the radius. The biceps tendon is thus the deep guide in this exposure, and the surgeon must keep strictly to its outer side or he may injure the ulnar vessels. The

recurrent radial vessels curve outward at the level of the bicipital tubercle, and can be hooked up on the finger and divided.

The finger then gains admission to the plane of cleavage between the pronator teres and the brachioradialis (*see Fig. 10*). The anatomy of this plane favours the surgeon, for the radial artery runs within the sheaths of the pronator teres and the flexor longus pollicis, while the radial nerve (superficial branch of the radial, B.N.A.) is attached to the long lateral muscles which flank the radius. The separation of these neighbouring structures is thus made easy.

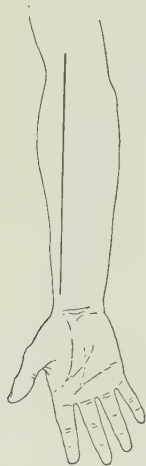


FIG. 9.—Incision for exposure of the radius. Divide skin and superficial fascia from the lower end of the biceps belly to the radial styloid. Begin dividing the deep fascia over the biceps tendon.

THE OPERATION.

Incision (*Fig. 9*).—With the patient's elbow extended and the hand supine, divide the skin and superficial fascia by a straight incision from a point at the outer edge of the biceps belly four finger-breadths proximal to the bend of the elbow

and terminating at the tip of the radial styloid. Divide and tie the large superficial vein which crosses the mid-third of the radius.

The Deep Guide.—First expose the biceps tendon by dividing the deep fascia at its outer side. Continue the division of the

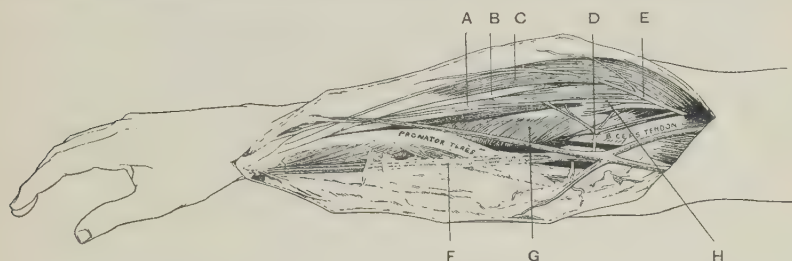


FIG. 10.—Exposure of the biceps tendon: slide a finger downwards along its outer side till it meets the resistance of the recurrent vascular loop D. Divide and tie this loop. Mobilize the three long muscles A, B, C, which flank the radius: flex the elbow and retract them outwards. A, Extensor carpi radialis brevis; B, Extensor carpi radialis longior; C, Brachioradialis; D, Recurrent vascular loop; E, Musculocutaneous nerve; F, Radial artery; G, Supinator; H, Posterior interosseous and radial nerves.

fascia throughout the wound with blunt-nosed scissors. Pass the finger distally along the outer side of the tendon till it meets the resistance of the recurrent vascular loop (*Fig. 10*). Hook it up gently on the finger; divide and tie it. Mobilize the three long muscles which flank the outer face of the forearm. Detach the flat tendon of the brachioradialis from its insertion into the base of the radial styloid. Flex the elbow



FIG. 11.—Showing the cut made through the bicipital bursa. Keep the knife close to the outer face of the biceps tendon. The supinator is then peeled off the radius. The arrow shows the direction of the cut through the bursa.

through 90° and retract the muscles widely out to expose the supinator.

Return to the biceps insertion: keep the knife close to its outer face and cut down upon the radial tuberosity (*Fig. 11*).

This cut divides the bicipital bursa, and the knife strikes the radial tuberosity where it lies in a bay formed by the supinator edge (*Fig. 8*). From this strategic point the rugine peels the

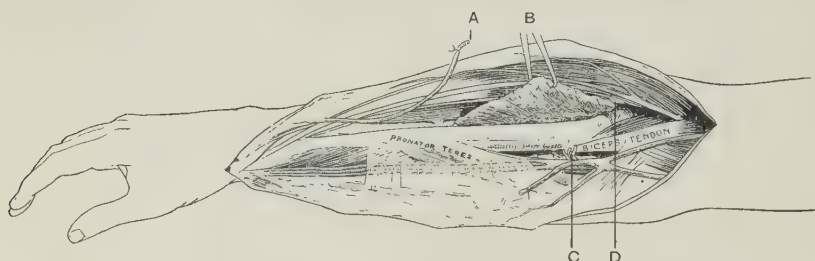


FIG. 12.—Completion of the exposure by putting the forearm in full pronation. A, Radial vein; B, Forceps retracting reflected supinator; C, Recurrent vascular loop (cut); D, Posterior interosseous nerve.

supinator muscle off the bone. The muscle is turned outwards, carrying within its substance the posterior interosseous nerve.

Put the forearm into a position of full pronation, and the radius will be revealed from end to end (*Fig. 12*).

EXPOSURES OF THE FEMUR

EXPOSURE OF THE FEMORAL SHAFT.*

EXPOSURE of the femur from the outer side of the limb is popular because it does not enforce reflection; the surgeon cuts down on bone with a feeling that the femorals are safe. The inconvenient, unsightly, and bloody wound suggests, however, that security has been attained at a price, and with a certain disregard for structure. The incision transects the oblique fibres of the vastus externus, the goal of four perforating arteries, and of the large descending branch of the outer circumflex; and unless the patient is maintained in a lateral position, the surgeon works in discomfort. The method described here respects anatomy, is relatively bloodless, and gives a wide and convenient exposure. Over twelve inches of the shaft, from the level of the small trochanter to the lower epiphysis, are freely available; the surgeon looks directly down on the front of the bone, and can see both sides of it in comfort.

ANATOMY.

The strong fascia of the thigh is loosely attached to the thin sheaths of the *rectus femoris* and *vastus externus*. When it is divided, the upper two-thirds of these muscles are easily separated by the finger, which finds the intervening plane of cleavage most easily a hand-breadth below the great trochanter (*Fig. 13*).

Near the patella the aponeurotic fibres of the vastus fuse with the rectus tendon, preventing further separation by the finger. When the rectus femoris and vastus are retracted, the silvery surface of the *crureus* (vastus intermedius of the B.N.A.)

* *Brit. Jour. Surg.*, 1924, xii, p. 84.

(Fig. 14) appears, and separation of its longitudinal fibres reveals the femoral shaft.

Two structures must be considered before the bone is exposed. The first is an oblique *neurovascular bundle* which consists of the descending branch of the external circumflex artery, its companion veins, and the nerve to the vastus

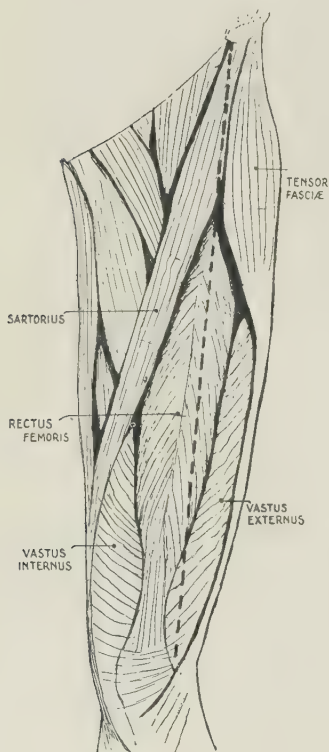


FIG. 13.—Cut through skin and fascia along the dotted line, from the anterior superior spine of the ilium to the outer angle of the patella. Find the plane of cleavage between the rectus femoris and vastus externus one hand-breadth below the great trochanter, where the rectus sinks into the angle between the sartorius and the tensor fasciæ.

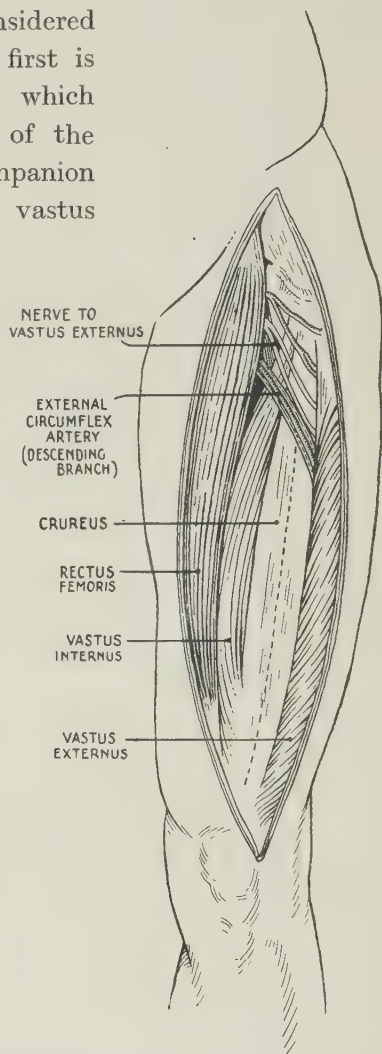


FIG. 14.—Separate the rectus femoris from the vastus externus, exposing the crureus, which is crossed obliquely by a neurovascular bundle (the descending branches of the external circumflex vessels and the nerve to the vastus externus). The artery shown above the nerve is the transverse circumflex branch lying in front of the neck of the femur.

externus. This bundle is found a hand-breadth below the trochanter. The second structure, the *suprapatellar pouch*, extends for the same distance above the pointed extremity of the patella. As each of these must be specially dealt with by the surgeon, they will be further described with the operation itself.

THE OPERATION.

Incision.—The skin and deep fascia are divided along a line from the anterior superior iliac spine to the outer angle of the patella (*see Fig. 13*).

Planes of Cleavage.—The finger finds the interval between the rectus femoris and vastus externus, a hand-breadth below the great trochanter, and the muscles are separated by means of the finger, which may meet one or two vessels passing to the rectus; these are caught and divided. In the lower third of the thigh the finger is checked where the aponeurotic fibres of the vastus join the rectus tendon, and the knife must be used to separate them. The blade is kept parallel to the face of the quadriceps tendon, and a plane of cleavage will be found in this trilaminar structure, between the contribution from the rectus and that from the vastus, which permits their separation down to the patella. *In septic conditions, however, the laminæ of the quadriceps tendon should not be separated beyond a level one hand-breadth proximal to the apex of the patella.* A small protrusion of the suprapatellar pouch sometimes pierces the tendinous contribution from the vastus externus below this level, and may be sliced open. The synovial cavity of the knee might thus be infected. When the two muscles are mobilized and drawn apart they expose the silvery surface of the crureus.

The Neurovascular Bundle.—The oblique descending branches of the external circumflex vessels and the nerve to the vastus externus are now seen passing across the crureus from beneath the rectus femoris to strike the free edge of the vastus externus, into which they sink. They run in a streak of fat, roofed by

thin fascia, and are easily mobilized by drawing a knife along its lower edge; they are retracted proximally (*Fig. 15*). The

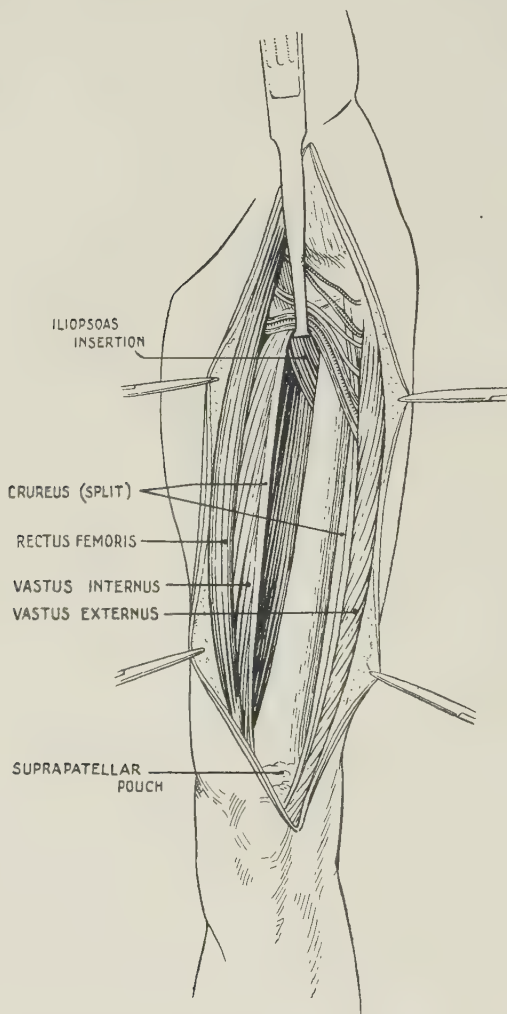


FIG. 15.—Mobilize and retract the neurovascular bundle. Split the crureus along the dotted line shown in *Fig. 14*. Avoid the suprapatellar pouch by checking the cut through the crureus one hand-breadth proximal to the pointed end of the patella.

surgeon can then cut to the bone through the upper portion of the crureus.

A large vein is often divided in this part of the muscle.

The Suprapatellar Pouch.—This, extending a hand-breadth above the apex of the patella, is easily avoided by checking the cut through the crureus above this level. The rugine works against the bone in a layer of fat, and separates the pouch from the femur.* If necessary, a retractor can be slipped between the pouch and the bone, and flexion of the thigh, relaxing the quadriceps, gives access to the lower end of the shaft.

When the two halves of the split crureus are separated from the bone and drawn apart, over a foot (32 cm.) of the femoral

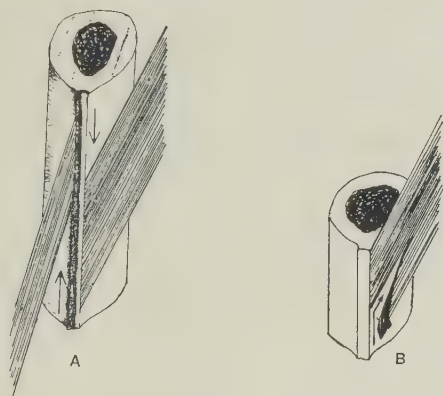


FIG. 16.—Work the rugine into the acute angle A which the muscular attachments make with the bone. B shows how the rugine tears into a muscle when used in the reverse direction against the obtuse angle.

shaft is exposed—from the lower epiphysis to the lesser trochanter. At the inner side of the shaft the attachment of the muscles to the linea aspera is visible. If it is necessary to clear the linea aspera, the direction of the fibres should be noted; the edge of the rugine should travel into the acute angle which they make with the bone. If the rugine is used in the opposite direction, it tends to leave the bone and tear into the muscle (*Fig. 16 B*). The direction of the muscle fibres varies, of course,

* Attempts at separating the pouch from the quadriceps tendon will as a rule tear the pouch. (The pouch, of course, communicates with the knee-joint.)

at the same part of the bone. Thus the adductors travel down *to* the femur, while the vasti and short head of the biceps travel down *from* the femur. These attachments are cleanly separated by proceeding with method.

The surgeon should begin on the inner side of the linea aspera. The thin origin of the vastus internus which constitutes the internal intermuscular septum (Poirier) is easily seen, and is detached from the linea aspera by working the rugine up along the shaft. The adductor insertions which form the next layer are then separated by using the rugine in the reverse direction.

On the outer side of the shaft the rugine is worked up against the origins of the vastus externus and short head of the biceps. The strong external intermuscular septum should be dealt with last; its lowest fibres are irregularly arranged, but its attachment to the linea aspera can be exposed to view by drawing the vastus externus towards the back of the thigh. If the surgeon then seats himself for a moment with his eyes level with the wound, the perforating vessels will be seen coming through the arched openings of the septum; and since the vessels are drawn backward in these roomy arches by retracting the muscles, they will not be injured when the septum is cut close to the bone.

Counter-openings for drainage may be made with perfect safety by cutting down on the tip of a forceps passed between the outer moiety of the crureus and the bone. The forceps follows the outer face of the external intermuscular septum, and since, in the recumbent posture, this septum is almost vertical to the bed, drainage is excellent.

EXPOSURE OF THE POPLITEAL FACE OF THE FEMUR.

This aspect of the bone is often the seat of inflammation. It is sometimes exposed from behind, a procedure which courts several disasters. It may readily be approached from (1) *The Inner*, or (2) *The Outer Side*.

1. THE INTERNAL (OR MEDIAL) EXPOSURE.

ANATOMY.

When the patient lies upon his back with his right foot placed upon his left shin, the neck of the right femur forms almost a right angle with the table; the popliteal plane has a similar inclination, and when, in addition, a small pillow is placed under the left buttock, the right popliteal surface looks slightly upwards as well as to the left.

Plane of Cleavage.—A convenient plane of cleavage gives access to the popliteal surface from the inner side of the limb. It lies between the popliteal vessels and the bone.

The tendon of the adductor magnus is the deep guide to the plane of cleavage (see Fig. 18). When the sartorius has been mobilized, the gracilis and the inner hamstrings (semitendinosus and semimembranosus) are easily retracted back, and the tendon of the adductor magnus is exposed. A thin fascia immediately behind the tendon is opened, and the finger, keeping contact with the tendon, enters the plane of cleavage. The vessels lie at some distance from the bone, and can easily and safely be separated from it.

THE OPERATION.

Position of Patient.—Put a sand-bag 3 in. thick under the buttock on the sound side, as he lies recumbent. Place the foot of the affected limb upon the opposite shin, as near the knee as possible.

Incision.—Make a longitudinal 8-in. cut which follows the bend of the limb, through skin and superficial fascia only, so that 2 in. of the cut lie distal to the adductor tubercle and 6 in. are proximal to it (*Fig. 17*). Dissect back the lower lip of the wound for about an inch. Expose the sartorius just proximal to the level of the adductor tubercle, and free the muscle by dividing the deep fascia along its anterior edge. To do this, slip one blade of the blunt-nosed scissors under the fascia, and thus avoid injuring the synovial membrane of the knee, which is subjacent to the sartorius when the joint is flexed.

The free sartorius falls back and exposes the tendon of the adductor magnus. The saphenous nerve leaves Hunter's canal in front of the tendon, and travels in this region deep to the sartorius (*Fig. 18*). Sometimes the muscle carries the nerve with it upon its deep aspect; sometimes the nerve is left like a lax string across the bend of the limb. It is accompanied by



FIG. 17.—Divide skin and deep fascia longitudinally for 8 in. following the bend of the knee: 6 in. of the cut lie proximal to the adductor tubercle; 2 in. are distal to it.

the superficial branch of the anastomotica magna (art. genu suprema, B.N.A.), some twigs of which may require division.* The internal saphenous vein lies superficial to the sartorius, and is not seen if the skin incision has been properly placed.

Pick up the thin fascia immediately behind the adductor tendon. Open it as one does the peritoneum. Thrust in the forefinger, keeping its back against the tendon till the nail strikes the bone at the middle of its popliteal face. The popliteal vessels lie at some distance—often an inch—behind this

* The deep branch of this vessel runs along the front of the adductor tendon in the substance of the vastus internus.

surface; bend the forefinger and gently hook them up. Work the finger along the bone and mobilize the vessels—proximally as far as the opening in the adductor magnus, and distally to the notch between the condyles of the femur. An assistant protects the vessels with a wide retractor, and draws them back with the sartorius. He draws forward the adductor tendon and the part of the vastus muscle which arises from it.

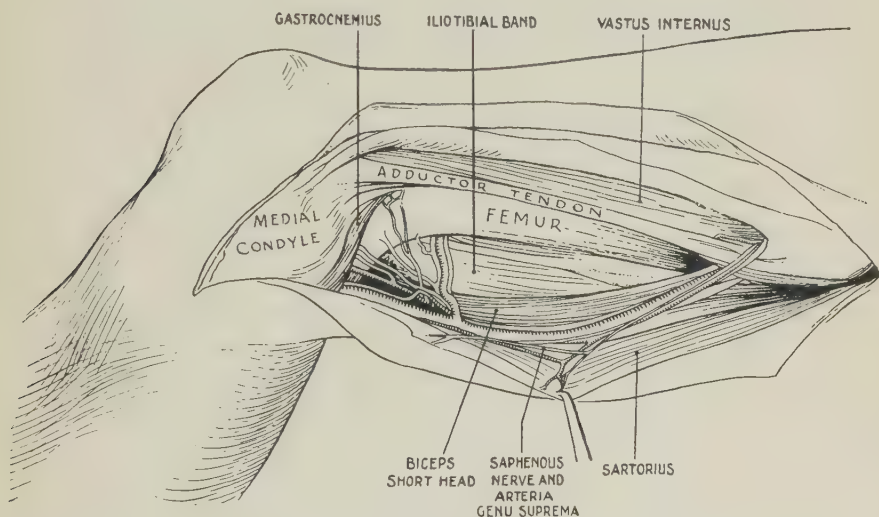


FIG. 18.—Dissect back the skin at the lower edge of the wound. Divide the deep fascia with blunt-nosed scissors, exposing the sartorius; retract it back and find the adductor tendon with the finger. Open the fascia just behind the tendon. Keep the back of the finger against the tendon, and thrust it into the popliteal fossa till it touches the middle of the popliteal face. Bend the finger and hook back the great vessels.

As the popliteal vessels are drawn back, the inconstant twigs which they send to the bone appear like strings across the wound; they are easily caught and divided, and the popliteal face of the femur is laid bare. (*See Fig. 18.*)

The internal and external popliteal nerves (the tibial and common peroneal, B.N.A.) are not seen; they lie in that part of the wound which is next the table, and are sufficiently remote from the bone to be out of harm's way.

2. THE EXTERNAL (OR LATERAL) EXPOSURE OF THE POPLITEAL FACE.

A simple exposure of this surface from the outer side is effected by taking advantage of a loophole, easily defined after the deep fascia has been divided. The finger entering this loophole can pass directly to the bone.

ANATOMY.

The Loophole.—The origin of the short head of the biceps from the lateral intermuscular septum extends to within about two finger-breadths of the outer femoral condyle ; the free muscle

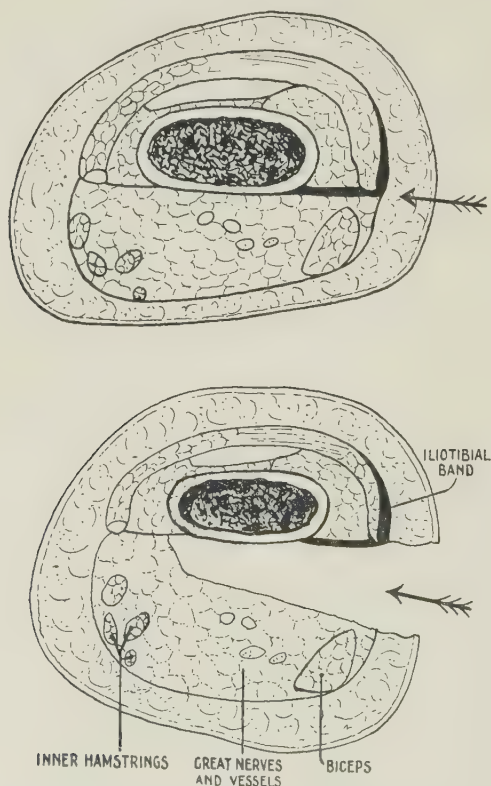


FIG. 19.—The arrow indicates the plane of cleavage between the biceps and the external intermuscular septum. The hinder edge of the iliotibial tract forms a right angle with the septum and marks its position.

then travels behind the septum. Within these two finger-breadths the surgeon can penetrate the popliteal space in the interval between the septum and the free biceps belly (*see Fig. 21*). The intermuscular septum is continuous with the hinder edge of the iliotibial tract (*Fig. 19*), which is easily felt on the surface of the limb. The hinder edge of the tract thus marks exactly the position of the septal partition.

When the knee is flexed, the tract follows the bend of the limb; its hinder edge then lies two finger-breadths in front of the biceps tendon, which crosses the bend.* As the biceps goes to its insertion on the fibula it passes across the gastrocnemius, and opposite the outer face of the external condyle makes direct contact with a small surface of the synovial membrane of the knee, which must not be injured when the biceps is mobilized.

THE OPERATION.

Position.—The patient lies on the sound side with the sound limb extended. Place the knee of the affected side just in front of the other knee, so that the heel on the affected side rests upon the other shin; this tilts the popliteal surface to a convenient angle (*Fig. 20*).



FIG. 20.—Divide skin and superficial fascia by a 6-in. incision along the hinder edge of the iliotibial tract (two finger-breadths in front of the biceps tendon), ending at the fibular head.

* The biceps tendon is a poor landmark when the knee is straight and the hamstrings are slack, and in itself is a deceptive guide in the exposure. It is not a free cordlike structure, but is merely an aponeurotic strip on the back of a wider belly; incisions close to its outer edge will cut into muscle.

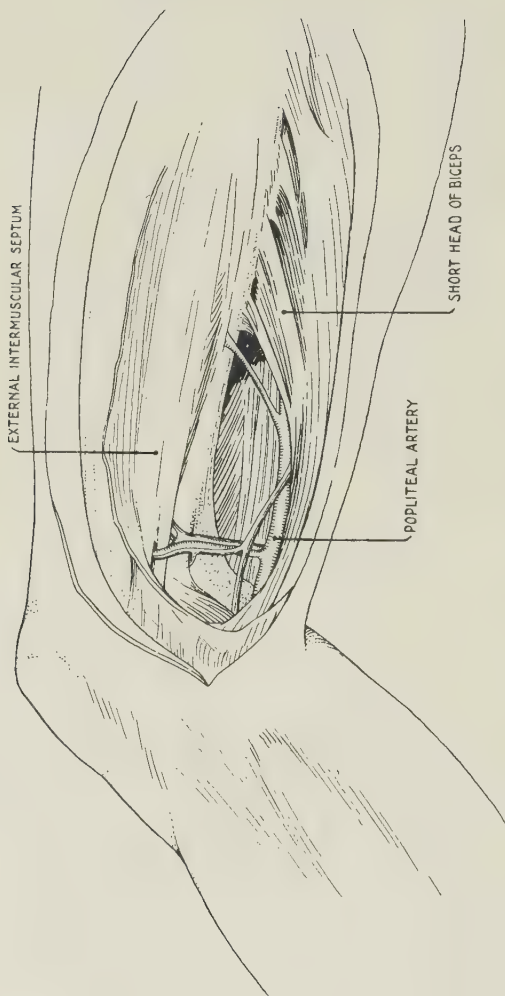


FIG. 21.—At a point just proximal to the condyle, open the deep fascia behind the hinder edge of the iliotibial tract. Thrust in a finger with its back touching the tract till it touches the middle of the popliteal face. Hook back the great vessels and nerves. (The figure shows the popliteal face seen through the loophole between the biceps and the external intermuscular septum. No muscle fibres are divided in this specimen.)

Incision.—Make a longitudinal 6-in. cut, through skin and superficial fascia only, along the hinder edge of the iliotibial tract two finger-breadths in front of the biceps tendon. The incision follows the bend of the limb and ends at the head of the fibula (*Fig. 20*). Pick up the deep fascia immediately behind the iliotibial tract; divide it in the line of the skin incision, using blunt-nosed scissors to avoid injuring the synovia of the knee. At a point just proximal to the condyle, pass the index finger into the plane of cleavage between the biceps belly and the intermuscular septum. Work the finger up along the septum, and gently separate the few and slender fleshy attachments of the biceps from its posterior face. As this is done, the finger will meet with two or three resistant strands—posterior branches which the perforating vessels give off before they pierce the intermuscular septum (*Fig. 21*). Divide and tie these branches. Then, keeping the back of the forefinger against the edge of the iliotibial tract, pass it into the popliteal fossa until the finger-tip touches the bone at the middle of the popliteal face. Gently hook up the popliteal vessels and mobilize them with the finger. Retract them back, together with the posterior wall of the wound.

The popliteal aspect of the bone is now completely exposed. The two great nerves of the space—the internal and external popliteal (tibial and common peroneal, B.N.A.)—are not usually seen unless they are sought. They lie on a plane slightly behind that of the vessels, and the short head of the biceps shelters them as they skirt its medial edge.

EXPOSURE OF THE FIBULA

ANATOMY.

THE neck and upper third of the fibula are in direct contact with nerves. Muscles surround three-fourths of the shaft.

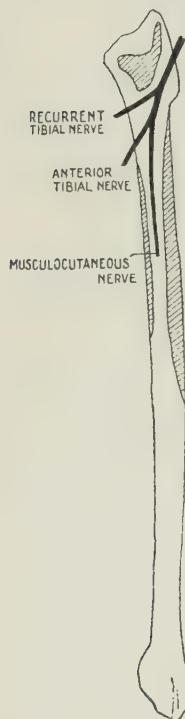


FIG. 22.—Diagram of left fibula (modified from Poirier) showing extent of bone in direct contact with nerves. The shaded areas are the three fibular origins of the peroneus longus. (No other muscle is represented.)

The relations of the nerves to the upper part of the bone are as a rule insufficiently described in British text-books, which give the impression that only the *neck* of the fibula is in contact with the branches of the external popliteal nerve (common peroneal, B.N.A.). A glance at *Fig. 22*, modified from that which accompanies Poirier's excellent account of the peroneus longus, shows in diagram the true extent of this contact.

It is, of course, at the fibular neck, where the nerves are thinly covered by the origin of the long peroneus, that they are most often exposed to violence, but the surgeon whose intervention is not to come within this category should be familiar with the true anatomy of the region.

The *external popliteal* (common peroneal, B.N.A.) gives off its last three branches as it lies upon the fibular neck: first, the recurrent tibial nerve, which is often double; then, anteriorly, its deep (or anterior tibial) branch; and, posteriorly, its superficial (or musculocutaneous) branch. This last nerve descends almost vertically along the shaft, separating the diaphysial origin of the long peroneus into anterior and posterior moieties, and keeping

contact with the upper third of the shaft. Distal to this the peroneus brevis separates the nerve from the bone.

Exposure of the upper half of the fibula requires a full mobilization of these nerves. This can be safely done by defining the trunk of the common peroneal as it descends behind the head of the bone (*see Fig. 24*). When the nerve is raised, it leaves a shallow groove which separates the muscles of the calf from the fibular head. This groove is a strategic point, and gives the surgeon entry to a plane of cleavage which allows him to separate the peronei from the soleus muscle, and thus expose the bone with least damage. By exposing the distal half of the fibula a plane of cleavage between the peroneus brevis and the extensor muscles can easily be found at the apex of the triangular subcutaneous area, but an exposure along this line should be limited to the distal half of the bone.

The following is a description of a complete exposure of the fibula.

THE OPERATION.

Position.—The patient lies on the sound side with the sound limb extended. Place the knee of the affected side just in front of the other knee so that the heel of the affected side rests upon the other shin (as in *Fig. 20*, p. 23).

Incision (*Fig. 23*).—Divide the skin and superficial fascia from the back of the external malleolus to the back of the fibular head; continue the incision along the biceps tendon for one hand-breadth beyond this. Open the deep fascia proximally, at the medial edge of the biceps tendon; continue its division

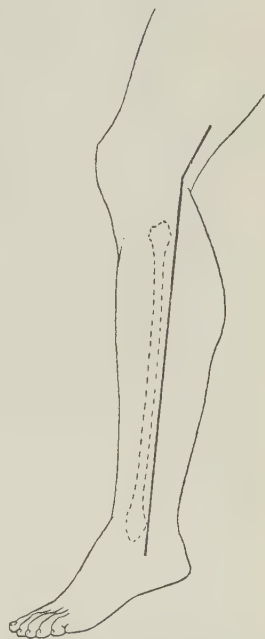


FIG. 23.—Divide skin and superficial fascia from the back of the external malleolus to the back of the fibular head. Continue the incision one hand-breadth along the biceps tendon.

with blunt-nosed scissors down behind the fibular head. Find the common peroneal (external popliteal) nerve where it lies flush with the tendon at the inner side of the biceps insertion. The tendon overlaps the nerve in the proximal part of the wound.) (*Fig. 24.*) Mobilize the nerve proximally till a loose

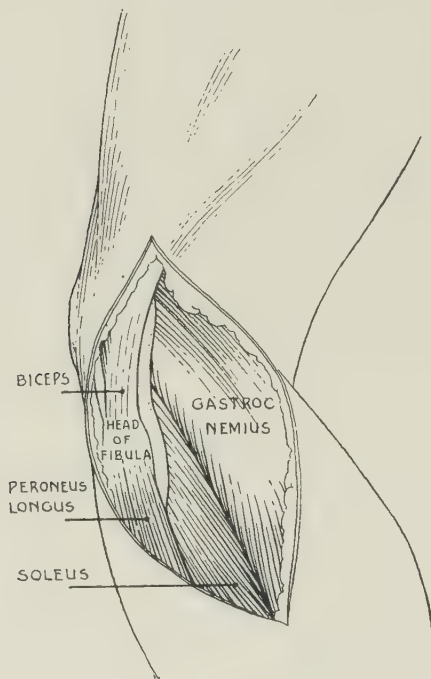


FIG. 24.—Open the deep fascia proximally over the biceps tendon; divide it. Expose the external popliteal nerve: it lies in a groove which separates the soleus from the fibular head. *This groove is the key to the plane of cleavage between the peronei and the calf muscles.*

loop of it can be drawn out across the tendon and the fibular head. Slip one blade of the scissors down along the groove which the nerve has left. Divide the deep fascia in the direction of the groove, and thus open the plane of cleavage between the soleus and the peroneal muscles.

Next, draw the nerve-loop distally (towards the foot); turn the knife's edge away from the nerve against the lower border

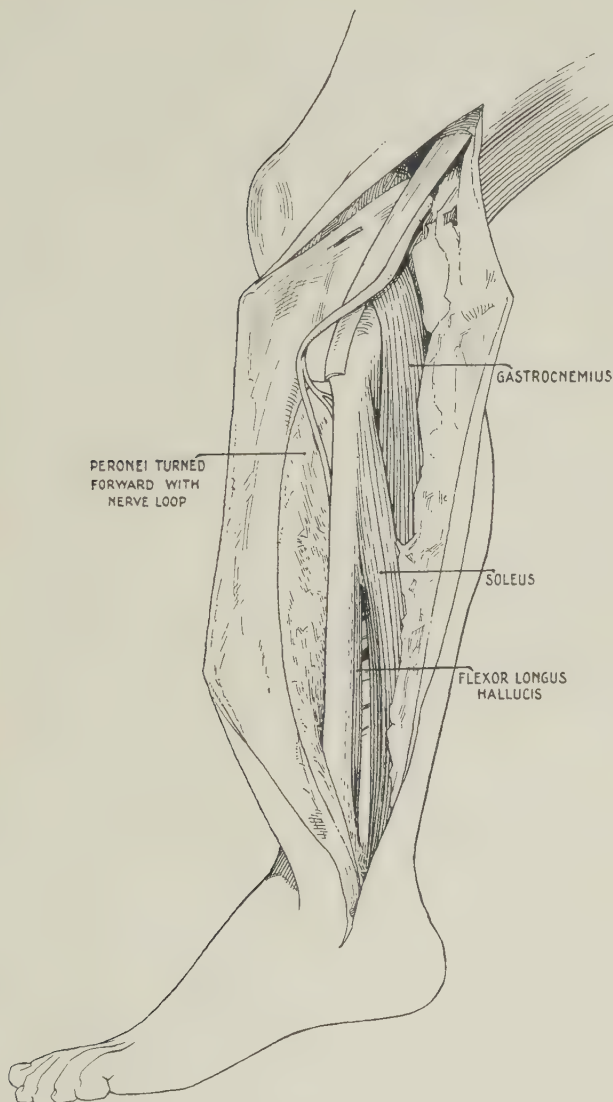


FIG. 25.—Mobilize the nerve and lift it from its groove. Slip one blade of a blunt-nosed scissors into the groove and divide the deep fascia throughout the wound. Separate the soleus from the peroneus longus. Draw the nerve-loop distally. Turn the knife-edge away from the nerve, and cut through the thin slip of peroneus which bridges it. Detach the peronei and turn them forward, keeping the nerve-loop taut.

of the fibular head, and divide the thin slip of peroneus longus which bridges the nerve as it branches upon the fibular neck (*Fig. 25*). The nerve-loop can thus be drawn still farther out and away from the bone, while the peronei are raised after it and turned forward.

The Peroneal Vessels.—About one hand-breadth distal to the knee-joint these vessels come to lie close against the tibial side of the fibula. They are avoided by keeping the rugine's edge still closer to the bone.

Section II

OTHER SURGICAL METHODS

EXPOSURE OF THE PLANTAR STRUCTURES

A CONVENIENT exposure of the structures of the sole of the foot may be obtained from the inner side. Incisions through the thick unyielding skin of the sole are unsurgical and, except for abscess, should be avoided.

ANATOMY.

The skeleton of the foot standing upon the ground forms an arched bony cage wide open on its inner side. This medial aperture, apart from the covering of skin, is closed by the wide belly of the *abductor hallucis*. When this muscle is suitably detached the contents of the cage are laid bare, and since the abductor hallucis belongs to the first, or most plantar, muscular layer of the sole, the finger can then enter the plane of cleavage between the first and second layers.*

In this plane the external (or lateral) plantar vessels and nerves pass obliquely forwards towards the outer edge of the foot. The internal (or medial) neurovascular bundle skirts the lower edge of the abductor hallucis. The two long tendons of the second layer (*see footnote*) cross each other where they touch

* The four muscular layers of the sole, numbered from skin to bone, may be considered as composed of two symmetrical layers (the 1st and 3rd), which alternate with two other layers (the 2nd and 4th) consisting each of two long tendons plus short muscles. The four layers are arranged in the following way :—

1st Layer (symmetrical)		
ABDUCTOR OF GREAT TOE	Flexor digitorum brevis	ABDUCTOR OF LITTLE TOE
2nd Layer (Two long tendons	+	Short muscles)
<i>Flexor hallucis longus</i>		<i>Lumbricals</i>
<i>Flexor digitorum longus</i>		<i>Accessorius (quadratus plantæ, B.N.A.)</i>
3rd Layer (symmetrical)		
SHORT FLEXOR OF GREAT TOE	Adductor hallucis	SHORT FLEXOR OF LITTLE TOE
4th Layer (Two long tendons	+	Short muscles)
<i>Peroneus longus</i>		<i>Interossei</i>
<i>Tibialis posticus</i>		

in the sole at a point one thumb-breadth to the outer side of the scaphoid tuberosity, the long flexor of the toes lying plantar to the flexor hallucis. The two tendons are bound here to the arch of the foot by a loose fibrous sheath.

The plantar nerves are found where they part company three finger-breadths posterior to the scaphoid tuberosity. The external plantar nerve here lies close against the accessorius (*quadratus plantæ*, B.N.A.), deep to the internal plantar, and nearer the sole by about a quarter of an inch. The internal plantar nerve runs in the loose fat between the abductor hallucis and the flexor brevis digitorum. The plantar vessels accompany the plantar nerves.

The structures of the third and fourth layers, with one exception, are confined to the anterior part of the sole; they cover the plantar face of the metatarsal bones and the distal edge of the tarsus. The exception is the tendon of the *tibialis posticus*. Apart from this, the posterior moiety of the second layer is in direct contact with the tarsal ligaments. The most obvious of these is the short plantar, whose oblique fibres are placed between the long plantar ligament laterally, and the inferior calcaneonavicular or 'spring' ligament on the medial side. Each of these ligaments can be seen and dealt with when the long flexor tendons have been mobilized and their accessory muscle (the *quadratus plantæ*) has been detached. The plantar face of the tarsus is then at the surgeon's disposal.

THE OPERATION.

Position.—The foot lies on its outer or fibular side.

Incision.—Divide skin and superficial fascia at the inner side of the foot from the ball of the great toe to the heel by a curved incision crossing the scaphoid tuberosity (*Fig. 26*). Find the tendon of the abductor hallucis at the inner side of the first metatarsal. Mobilize the tendon, working back towards the heel. Use the tendon as a guide to the belly, and detach the muscle first from its fascial connection with the scaphoid



FIG. 26.—Divide skin and superficial fascia from the ball of the great toe to the heel. The highest part of the incision crosses the scaphoid tuberosity (x). Reflect the skin flap downwards and find the tendon of the abductor hallucis at the inner side of the 1st metatarsal.

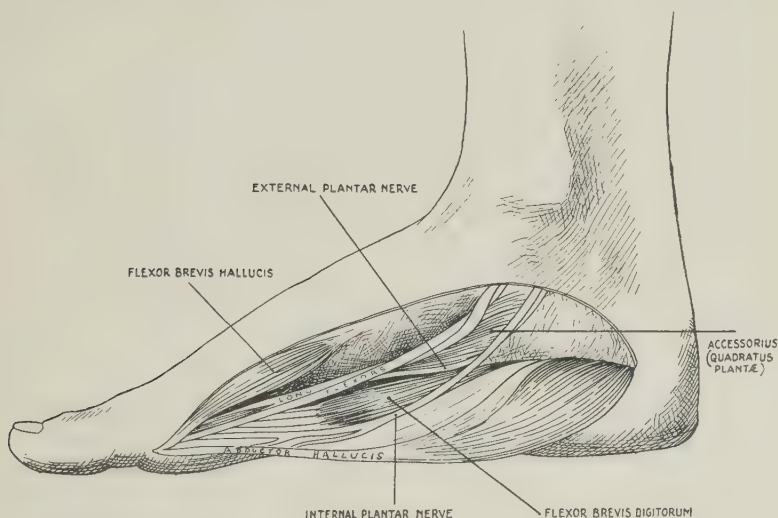


FIG. 27.—Exposure of the plantar structures obtained by detaching the abductor hallucis. Mobilize the tendon of the abductor hallucis; use it as a guide to the belly. Detach the muscle down to the tubercle of the os calcis and turn it inward towards the sole through a full right angle. The scaphoid tuberosity is the deep guide. The long flexor tendons of the 2nd layer cross a thumb-breadth external to it. Three finger-breadths behind it the external plantar nerve leaves the internal and passes forwards and out across the sole between the 1st and 2nd layers, the two nerves forming a > (see text). The long flexor tendons, with the accessorius behind and a lumbrical in front, are seen separating the 1st layer from a muscle of the third (flexor hallucis brevis).

tuberosity, and then *carefully* from the indefinite anterior portion of the vague internal annular ligament (laciniatè ligament, B.N.A.).* The plantar vessels and nerves lie deep to this part of the muscle. It is important that the abductor hallucis should be thoroughly detached down to its origin from the inner tubercle of the calcanean tuberosity. The muscle can then be turned inward towards the sole through a full right angle (*Fig. 27*).

The remainder of the operation varies with the object of the exposure. The structures available are described under the heading 'Anatomy', p. 33.

The nerves and corresponding vessels should be located early. The two long flexor tendons can be relaxed by flexing the toes and twisting the foot into a position of equinovarus. If they require further relaxation, they can be mobilized through a supplementary incision which extends up behind the internal malleolus, and across this they can then be dislodged.

* " Its proximal border . . . is very imperfectly defined. Its distal margin is but little more distinct, being continuous more or less with the tendinous origin of the abductor hallucis which arises from it." (T. H. Bryce in *Quain's Elements of Anatomy*, 11th ed., 1923, p. 248.)

A METHOD OF LIGATING THE SECOND STAGE OF THE VERTEBRAL ARTERY

THE second stage of the vertebral artery begins at the foramen in the 6th cervical transverse process, and ends at the atlas vertebra (*Fig. 28*).

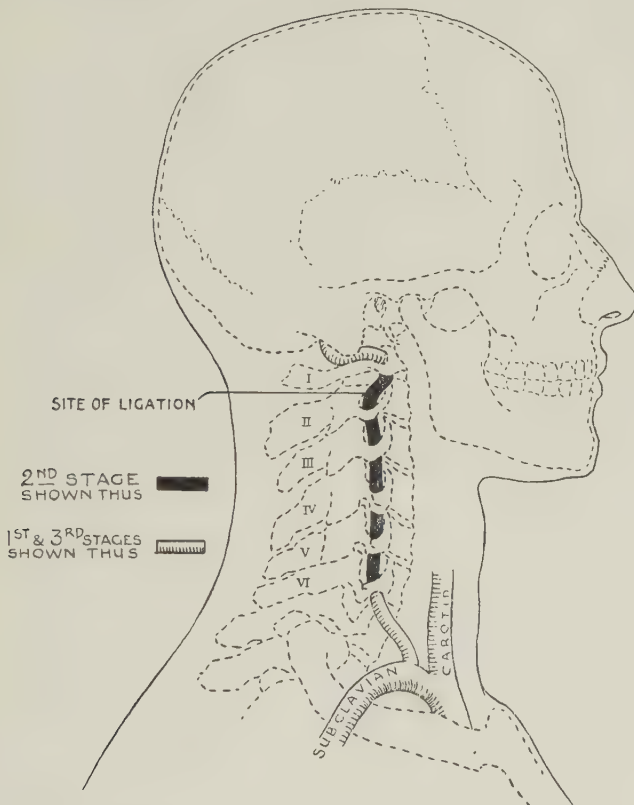


FIG. 28.—The vertebral artery in the neck, showing the second stage and the site for ligature.

Ligation of the vertebral elsewhere than in the first stage has usually been performed where the artery lies in its third moiety upon the atlas arch. Even in the cadaver the passage

of a needle round this atlantal portion of the vessel tears the large venous plexus which envelops it, and, whatever method of exposure is used, the vessel remains deeply placed in a limited field.

Injury to the venous plexus, with serious loss of blood, occurred in the two cases in which ligation of the third stage has been recorded,* and it seems desirable to describe a simple method of tying the second stage of the artery, particularly as forcible hæmorrhage from the cephalic end of the vessel has occurred in cases where the vertebral was injured.

Actually, the question of ligating this part of the vertebral was brought to my notice in the case of a large innominate aneurysm which had been treated with partial success by tying the right subclavian and common carotid trunks. A further intervention appeared necessary, and ligation of the right vertebral was considered, but the shadow of the aneurysm seen on a radiogram extended from the aortic arch to the transverse process of the seventh cervical vertebra, and discouraged ligation of the first stage.

The following method of tying the second stage was therefore devised.†

ANATOMY.

In the normal adult skeleton the breadth of the examining thumb will lie comfortably between the transverse process of the atlas and that of the axis vertebra ; three-quarters of an inch of the vertebral artery are available in this interval. Elsewhere in the neck the intertransverse spaces are comparatively small and are less easily identified. The second stage of the

* Lauenstein, R., *Zentralb. f. Chir.*, 1918, xlv, 149 ; and Schemmel, E., *ibid.*, 1918, xlv, 871.

† I am indebted to Sir F. Conway Dwyer for his courtesy in giving me the opportunity of seeing this case at the Richmond Hospital, Dublin. His ligation in March, 1925, of the right carotid and subclavian resulted in immediate diminution of the aneurysmal swelling, which at first was slight, but when the patient returned five weeks later for the proposed ligation of the second part of the vertebral the tumour had so shrunk that the operation was not then indicated.

vertebral is thus most readily exposed between the atlas and axis (*see Fig. 28*).

Under the cutaneous, platysmal, and fascial coverings of the neck, four structures must be dealt with at successive depths:—

1. The *sternomastoid muscle*.

2. The *spinal accessory nerve*, which enters the muscle two (or sometimes three) finger-breadths below the tip of the mastoid process, running as a rule in a layer of fat and often obscured by lymphatic glands (*see Fig. 31*).

3. The dense *prevertebral fascia* lying deep to the fat.

4. The stout and quite separate first slip of the *levator scapulæ muscle* arising from the tip of the transverse process of the atlas (*see Fig. 32*).

Deep to this muscular slip is the first intertransverse space, bounded in front and behind by an intertransverse muscle, and containing the part of the vertebral artery to be tied (*see Fig. 33*).

The *posterior intertransverse muscle* is as a rule very feebly developed and does not screen the artery. The *anterior intertransverse muscle*, too, in itself does not conceal the vessel, but it is often continuous laterally with the first slip of the *splenius cervicis* (*Fig. 29*), and in that case this muscular sheet may be partly drawn over the artery when the atlas turns with the patient's head to the opposite side. Remembering this, these small muscles present no difficulty to the surgeon.

The *internal jugular vein* (*see Fig. 31*) is in danger during the definition of the spinal accessory if the dissection is carried in front of the tips of the transverse processes.

The anterior primary division of the second cervical nerve crosses the vertebral artery transversely and lies close against it (*see Fig. 33*).

Bony Landmarks.—The deep guide in this ligation is the tip of the long transverse process of the atlas (x, *Figs. 31, 32*). It should be unmistakable when the sternomastoid has been

mobilized, and is felt one finger-breadth below, and one in front of, the mastoid tip.

The transverse process of the axis, on the other hand, is much shorter, and may be confused with a bony eminence behind and below it which consists of the articular process of the axis and that of the third cervical vertebra. During the

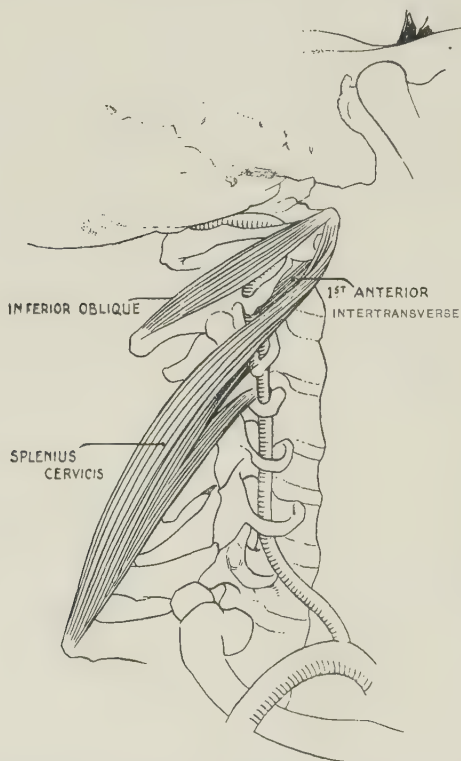


FIG. 29.—Showing how the splenius cervicis may blend medially with the 1st anterior intertransverse muscle. The right vertebral may be partly hidden by these muscles at the seat of ligature when the head (with the atlas) is turned to the left. This rotation draws the vessel quite clear of the inferior oblique muscle.

operation this joint becomes surprisingly prominent when the head is turned.

These two bony points may be distinguished in the following way. On the right side, when the right index finger-tip of

the surgeon, pointing to the patient's head, rests on the projecting joint, the tip of the mid-finger alongside (and touching the index) rests precisely on the transverse process of the axis.

THE OPERATION.

Position.—The patient lies on his back with the neck extended and the chin turned away from the vessel to be tied.



FIG. 30.—Divide skin, platysma, and fascia along the anterior border of the sternomastoid from the cricoid level to the skull. Cut backwards to the bone across the base of the mastoid, dividing the insertion of the sternomastoid and some fibres of the splenius capitis.

Incision (*Fig. 30*).—The skin, platysma, and deep fascia are divided along the anterior border of the sternomastoid from the cricoid level to the skull. The knife then turns back across

the base of the mastoid and cuts to the bone, dividing the sternomastoid insertion with a small part of the splenius capitis.

Mobilize the sternomastoid and turn it outwards through a right angle (*Fig. 31*).*

Define the spinal accessory nerve, which enters the sternomastoid two (or three) finger-breadths below the mastoid tip.

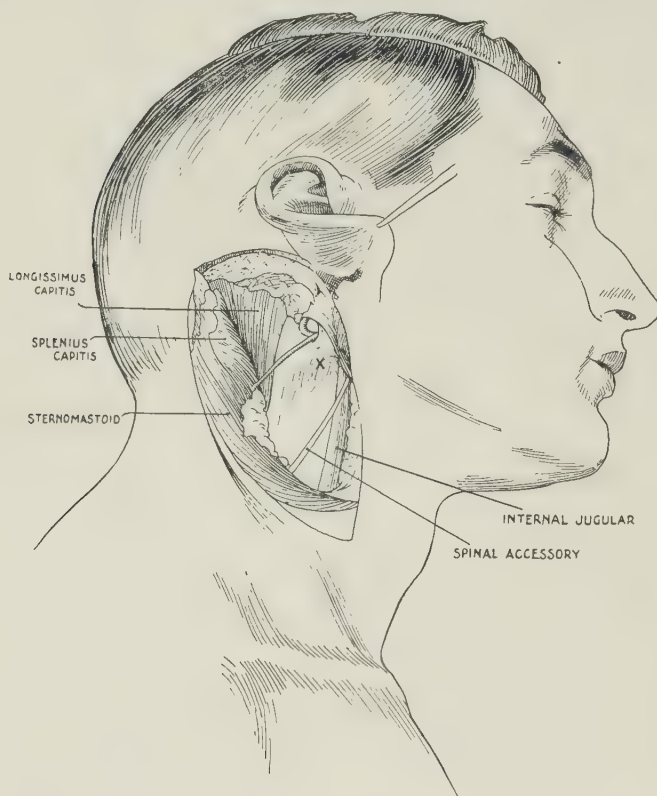


FIG. 31.—Mobilize the cut sternomastoid and turn it outwards through a right angle, exposing a layer of fat through which the spinal accessory nerve runs obliquely. Define the nerve, and from the tip (X) of the transverse process of the atlas (deep guide) cut through the fat parallel to the nerve. Expose the pre-vertebral fascia and divide it in the same line. Do not injure the internal jugular vein. (The occipital artery and its muscular branch are above the field of the deep dissection and need not be defined.) (N.B.—*Longissimus capitis* is the B.N.A. term for trachelomastoid.)

* This detachment and eversion of the mastoid end of the muscle is invaluable as a first step in the ordinary removal of cervical glands in malignant cases.

In doing this avoid the internal jugular vein by keeping the dissection *posterior* to the tips of the transverse processes.

Feel the deep guide, i.e., the tip of the transverse process of the atlas. Pick up and divide the thick prevertebral fascia obliquely downwards from this bony point parallel with the spinal accessory (*Fig. 32*). The stout, and quite separate,

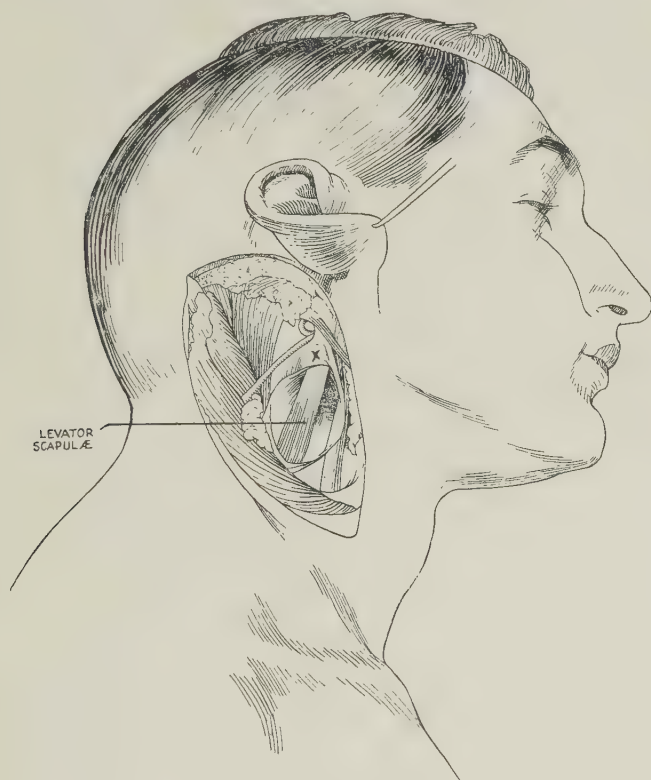


FIG. 32.—Divide the prevertebral fascia parallel to the course of the spinal accessory. The nerve is retracted as the fascia is opened. The quite separate first slip of the levator scapulæ is then exposed.

origin of the levator scapulæ from the atlas is thus exposed. Define it just below the atlas in the same way as a vessel is defined: use an aneurysm needle and divide the muscle upon it. A few shreds of muscle disturbed by the needle will often

remain (anterior intertransverse fibres *plus* fibres from the splenius capitis). Divide these too upon the needle. The vertebral artery is then seen running upwards and forwards.

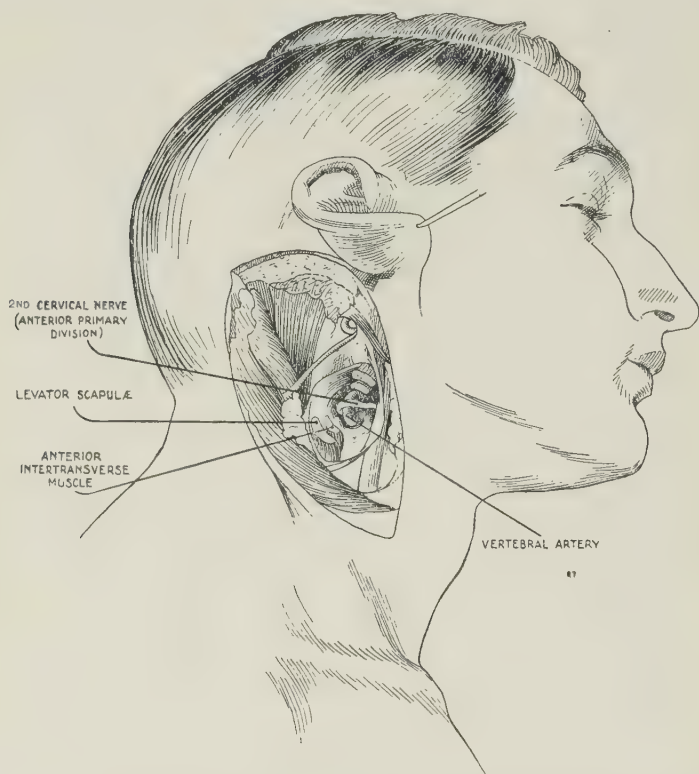


FIG. 33.—Pass an aneurysm needle round the slip of the levator scapulæ as if it were an artery. The anterior intertransverse muscle (deep to the levator) may also require division. The vertebral artery, crossed by the anterior primary division of the 2nd cervical nerve, is then fully exposed between the atlas and the axis.

It is crossed transversely by the anterior primary division of the second cervical nerve, which can be mobilized or divided (*Fig. 33*). Pass the ligature from the inner side of the vessel.

A METHOD OF LIGATING THE FIRST STAGE OF THE LEFT SUBCLAVIAN ARTERY FROM BEHIND*

WHILE engaged in investigating an approach to the cervico-dorsal ganglion upon the cadaver (*see* p. 58), I came almost by accident on a relatively simple method of ligaturing the first stage of the left subclavian artery. After demonstrating this method upon several occasions in the School of Anatomy of the Royal College of Surgeons in Ireland, I found that another posterior approach had been used by Sherrill in 1910 and published by him in 1911.† Only 21 cases of ligature of the left subclavian in its first stage are on record, and 7 of these were performed since Sherrill's operation, which is the solitary instance of a posterior approach to this forbidding artery. [Since this was written, Mr. W. A. Hailes (1925) has successfully tied the vessel, using the posterior route which I describe here. (*See* Note on p. 54.)]

The anterior approach to the left subclavian is notoriously difficult; a formidable array of nerves and vessels screen the artery. Through these but narrow access is gained, even after resection of the inner end of the clavicle, the first rib cartilage, and part of the manubrium. In actual practice, too, the upward bulge of an aneurysm into the neck will not simplify the surgeon's task. The posterior route has the merit of simplicity, and surgery advances through simplification to security. I

* *Brit. Jour. Surg.*, 1923, x., p. 367.

† Sherrill raised a flap of skin and muscle and removed about three inches of the 2nd, 3rd, and 4th ribs. After pushing aside the pleura, the artery was exposed at the level of the 4th dorsal vertebra as it left the aorta.—*Trans. Southern Surg. and Gyn. Assoc.*, xxiii, quoted by W. S. Halstead in *Johns Hop. Hosp. Rep.*, xxi, fasc. i.

thus venture to describe in detail the route upon which I chanced.

The transverse process of the second dorsal vertebra, and three inches of the second rib, measured from its head, were removed from the left chest of a hunchbacked cadaver after carefully separating the rib from the parietal pleura. In effecting this separation the pleural dome was slightly depressed, and the first stage of the left subclavian artery appeared in the field. Further separation and depression of the pleura exposed the artery from its point of origin at the aortic arch to the first rib, and definition of all its branches except the thyrocervical trunk was easy. These structures were rendered surprisingly superficial by the kyphotic deformity of the back. Examination of normal subjects showed that in them the left subclavian artery and its branches are farther from the dorsal surface of the trunk. The first stage of the artery, however, is just as easily tied in spite of the depth at which it lies, for once the lung and pleura have been depressed, the artery, except for a delicate sheath, lies naked in the thoracic cavity, and is immediately accessible. There is no barrier of vein or nerve; the vessel is directly under the finger. With a suitable needle it is easy to pass a ligature round the artery, and at my request this was done by students who had never previously tied any vessel in the body. Before describing the steps of the operation, certain anatomical points must be dealt with.

ANATOMY.

The Muscular Planes.—The part of the second left rib which is removed lies between the scapula and the vertebral spines: it is concealed by muscles which anchor the scapula to the vertebræ. The trapezius is spread over the rhomboids, which cover the upper serratus posterior. Division of these muscles allows the surgeon to widen the space between the scapula and the spine, and it is essential that the transverse width of the wound should be as great as possible. Deep to the muscles of

the shoulder girdle, the splenius spreads upwards from the dorsal spines; and lateral to the splenius are the cervical extensions of the erector spinæ (*Fig. 34*).

The Second Rib.—The second rib must be accurately identified. It is not difficult to mistake it for the first, and thus in error to remove the third rib. The second rib and transverse process

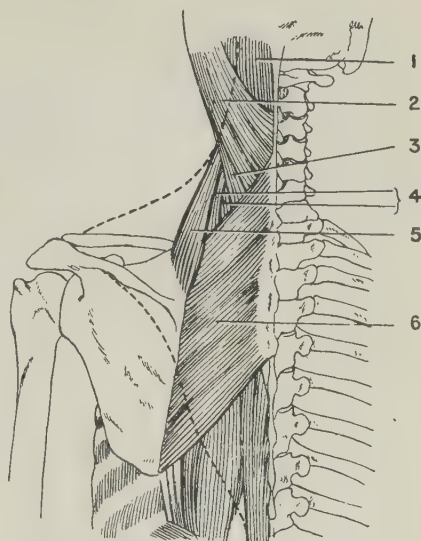


FIG. 34.—Showing the muscles that lie deep to the trapezius, which is indicated by the dotted line. (1) Complexus. (2) Splenius capitis. (3) Splenius cervicis. (4) Cervical extensions of erector spinæ. (5) Levator scapulæ. (6) Rhomboids.

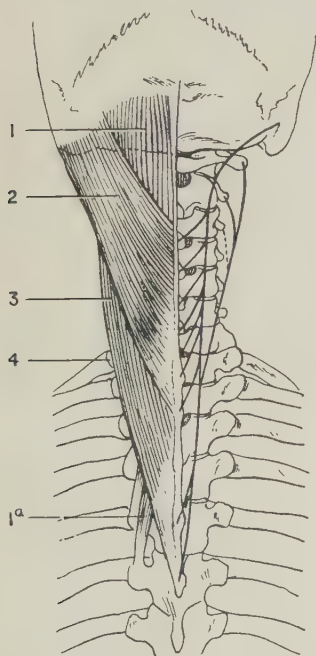


FIG. 35.—The 1st dorsal transverse process is the first which projects beyond the edge of the splenius. It forms a deep landmark for identifying the 2nd rib. (1) Complexus. (2) Splenius capitis. (3) Splenius cervicis. (4) 1st dorsal transverse process. (1a) Complexus.

viewed from behind lie dorsal to the first, and the body of the first rib runs almost directly forwards from the costotransverse articulation; it is difficult to palpate. When, however, the trapezius and the other muscles passing to the scapula have been divided and retracted, the first rib can be felt by hooking the finger deeply down along the neck.

The first dorsal transverse process is a good landmark (*Fig. 35*): it lies at the level of the 7th cervical spine, three finger-

breadths from the middle line. It is the first transverse process to project beyond the edge of the splenius. Here its tip is felt but is not seen, being covered by two cervical extensions of the erector spinæ (the iliocostalis cervicis and the longissimus cervicis). Reckoning from this landmark, the surgeon finds the second transverse process and the second rib.*

The Left Subclavian Artery.—The anterior relations of this artery in its first stage make an impressive list. Deep to the muscular planes consisting of the sternomastoid, sternohyoid, and sternothyroid, lie the left innominate, internal jugular,

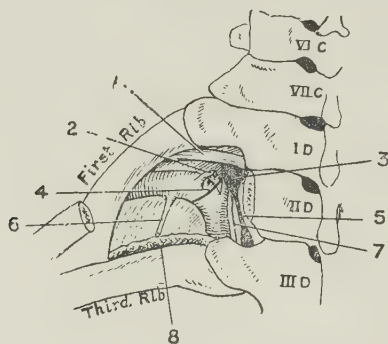


FIG. 36.—The relations of the first stage of the left subclavian artery seen from behind after removal of the 2nd dorsal transverse process and part of the 2nd rib. The œsophagus, and the thoracic duct which stripes its left side, are not shown in the figure: they are nearer the middle line. To see the origin of the subclavian artery from the aortic arch and to tie the *proximal* part of the artery, the surgeon stands opposite the head of the table. (1) 1st dorsal nerve. (2) Costocervical trunk. (3) 1st dorsal ganglion of sympathetic concealing vertebral artery. (4) Ansa subclavia crossing subclavian artery. (5) Sympathetic cord passing to 2nd dorsal ganglion. (6) Internal mammary artery. (7) Inferior cardiac branch of sympathetic. (8) Pleural dome retracted downwards.

and vertebral veins, succeeded by the vagus and phrenic nerves, the carotid artery, and branches of the cervical sympathetic. In the posterior approach, however, when the pleural dome has been depressed, only one minute structure intervenes between the surgeon and the artery—the ansa subclavia of Vieussens.

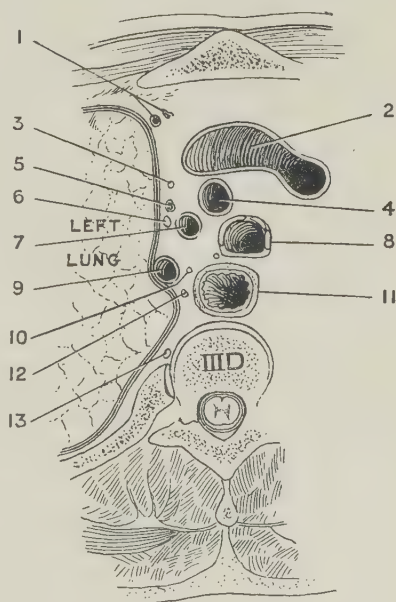
* For additional security, the second rib should be localized by radiography before operation, and the radiologist should be asked to examine the thoracic inlet for accessory cervical or rudimentary thoracic ribs, which might confuse the surgeon approaching them from behind.

This tough but slender loop crosses the back of the subclavian as the vessel arches after giving off its vertebral branch (*Fig. 36*). The depth of the proximal part of the artery from the dorsal surface is about three inches; that is to say, if the index finger could be thrust through the skin it would just touch the artery. By making a large flap as described below, the thickness of the skin and subcutaneous tissue is eliminated from the field, and suitable division of the muscles to the shoulder girdle allows the surgeon to work *from the plane of the thoracic wall*. The 'working depth' of the artery is thus reduced to two inches, which is the actual depth of the artery from the upper border of the manubrium in front. The 'working depth', therefore, is the same whether the approach is from the front or back.

The Left Vagus.—The presence of the left vagus need not be feared. The relations of the nerve depicted in most text-

FIG. 37.—Cross-section through 3rd dorsal vertebra and upper part of manubrium, showing relations of left subclavian artery. Note that the left vagus is still a satellite of the common carotid; the thoracic duct adheres to the oesophagus and is in no danger of injury.

- (1) Internal mammary vessels
- (2) Left innominate vein
- (3) Phrenic nerve
- (4) Innominate artery
- (5) Left superior intercostal vein
- (6) Vagus nerve
- (7) Left common carotid
- (8) Trachea with left recurrent laryngeal nerve
- (9) Left subclavian artery
- (10) Inferior cardiac branch of cervical sympathetic
- (11) Oesophagus
- (12) Thoracic duct
- (13) Sympathetic cord lying in front of costovertebral joint between rib and vertebral body



books of anatomy are those which it assumes after it has been freed by dissection. It then falls away from the common

carotid, and lies close in front of the first stage of the subclavian. If this were its true position, it would be in danger when the artery was tied from behind. Actually the nerve is, as Charpy* states, a satellite of the common carotid, and passes downwards and inwards close along this artery, coming gradually forwards as it descends: it thus lies beside, rather than behind, the left carotid at the root of the neck, and is on a plane anterior to the left subclavian (*Fig. 37*). About a finger-breadth above the aortic arch the direction of the vagus changes abruptly; the nerve passes out, down, and back, to cross the root of the left subclavian artery, so that this part of the vagus lies between the vertical carotid and subclavian origins of the left side like the oblique stroke of the letter N (*Fig. 38*).

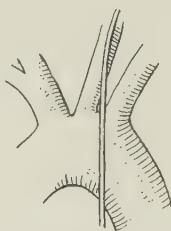


FIG. 38.—Diagram showing left vagus related to the left carotid and left subclavian arteries like the oblique stroke of the letter N. The vagus is safe from inclusion when the left subclavian artery is tied from behind.

Further, there is a barrier between the vagus and the subclavian which protects the nerve from inclusion when the artery is tied by the posterior route. This barrier consists of a layer of areolar tissue which contains: (1) The middle and sometimes the superior cardiac branch of the cervical sympathetic; (2) Descending œsophageal and tracheal branches of the inferior thyroid artery; (3) An occasional thymic tributary of the vertebral vein. These structures not only make it difficult to expose the subclavian from in front, but obscure the origin of the vertebral artery, which tends to lie at a relatively low level on the left side.

* Poirier and Charpy, *Traité d'Anatomie*, 2nd ed., vol. ii, pt. 1, p. 426.

The Left Vertebral Artery.—This vessel during development is often absorbed into the aortic arch, and seen from in front may be mistaken for the subclavian, since it then arises from the arch to the left of the left common carotid. This error will not be made in ligation from behind.

The Thoracic Duct and the Inferior Cardiac Nerve.—The thoracic duct will not be injured from the back; it stripes the left side of the œsophagus in the superior mediastinum, and only leaves it to pass in front of the root of the vertebral artery. In an anterior attack the duct, though not in contact with the first stage of the subclavian, may be injured as it arches outwards over the vertebral origin.

The inferior cardiac branch of the sympathetic also lies medial to the artery. With the most ordinary care it is easily avoided (*see Fig. 36*).

THE OPERATION.

A good headlight should be used, but in the cadaver I have repeatedly tied the artery without artificial illumination. The

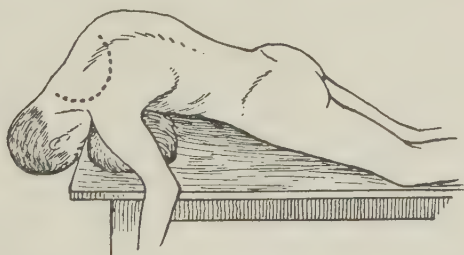


FIG. 39.—Showing skin incision and position securing maximum abduction of the scapula.

patient should lie prone, with the left shoulder clear of the table and the left upper limb hanging vertical (*Fig. 39*). Make the upper dorsal region as kyphotic as possible. This gives the space between the scapula and the vertebral column its maximal width.

1. Find the 7th cervical spine. Mark: (a) A point four

finger-breadths above it and one finger-breadth to the *right* of the middle line; (b) A similar point six finger-breadths below the 7th spine; (c) A point over the middle of the spine of the left scapula. Join these three points by the incision shown in *Fig. 39*, which is carried down to the sheath of the trapezius muscle. Raise the flap of skin and subcutaneous tissue thus outlined and turn it over to the *right* of the middle line.

2. With a vertical cut one finger-breadth to the left of the vertebral spines, divide the origins of (a) the trapezius, (b) the rhomboids, and (c) the serratus posterior superior. Do this first at the middle of the wound where the silvery tendon of the serratus indicates the depth reached. Extend this incision throughout the entire length of the wound. Retract the divided muscles outwards. The pointed caudal end of the fleshy splenius is now exposed.

3. At the level of the 7th cervical spine, and three finger-breadths from the middle line, find the tip of the first left dorsal transverse process, remembering that it is the first which projects beyond the edge of the splenius. Find the second left rib.

4. Clear the transverse process of the second dorsal vertebra as far as the lamina. Clear at least three inches of the second rib. Divide the transverse process at its root and remove it. Divide the rib as far as the wound will permit from the costo-transverse articulation.

5. Raise the proximal cut end of the rib. With finger push the pleura away from its head and neck. Rotate the rib segment and divide its attachments. The sympathetic cord is now seen close to the vertebral body, lying on the pleura like a tape.

6. Very gently push the pleural dome downwards and outwards from the vertebræ. A small strand will now be found holding the pleura to the neck of the first rib. This strand is a branch of the superior intercostal artery. Divide and tie it. The pleural dome can then be freely depressed, and the left subclavian is felt by the finger passed vertically and at a tangent to the vertebral body. *The removal of the transverse process.*

together with the costal neck, permits of this direct approach. A broad malleable retractor keeps the lung and pleura out of the field. It should be polished so as to reflect light into the cavity. The artery is isolated under direct vision by blunt dissection, and its sheath is opened in the usual manner, using a long dissecting forceps. The ansa subclavia should be avoided.

7. The surgeon stands facing the head of the table. An aneurysm needle with a slot eye (or, better, the cup-and-ball needle described on p. 55) is passed with the *left* hand from within outwards: introduction of the right forefinger into the wound facilitates this manœuvre. The eye is threaded with a ligature, or with a guiding thread to which a definitive ligature (a tape, for example) is attached. Ample space is afforded for securing the knot.

The internal mammary and costocervical trunks can be tied at their origins. The vertebral artery is obscured by the cervicodorsal ganglion of the sympathetic, but can be safely ligatured by opening the subclavian sheath close to the vertebral origin and passing an aneurysm needle round the parent trunk so that its point appears in the angle between the subclavian and the vertebral artery. The thoracic duct may thus be avoided. The thyroid axis (thyreocervical trunk, B.N.A.) is difficult to secure by the posterior route.

For the figures illustrating this article I am indebted to the text-books of Cunningham, and of Poirier and Charpy, from which they have been modified.

SUMMARY.

An approach to the first stage of the subclavian artery is obtained by costo-transversectomy at the level of the second rib on the left side. Depression of the pleural dome leaves the artery naked from the aorta to the first rib, no structure (excepting the ansa subclavia) intervening between the operator and the vessel.

The first stage of the vessel can be ligatured in any part of its course, and its branches, except the thyreocervical trunk, can be tied with relative ease.

Note.—While these papers were being arranged for publication I had the pleasure of receiving a letter from Mr. W. A. Hailes, of Melbourne, Australia, in which he most kindly gives me an account of his success with the above method (Feb., 1925) in the case of a left subclavian aneurysm the size of a cricket-ball. The ligature was placed about three-quarters of an inch above the aortic arch. Mr. Hailes expresses the belief that his case was inoperable from in front “even with a resection of the clavicle and sternum”.*

* This case has since been published by Dr. R. J. Wright-Smith, Medical Registrar, Melbourne Hospital. *Med. Jour. Australia*, May 21, 1927, p. 754.

A CUP-AND-BALL ANEURYSM NEEDLE FOR DEEP LIGATIONS *

WHILE investigating the posterior approach to the first part of the left subclavian artery, which is described in the preceding pages, I asked the students in the dissecting-room of the Royal College of Surgeons, Ireland, to test the description and sim-

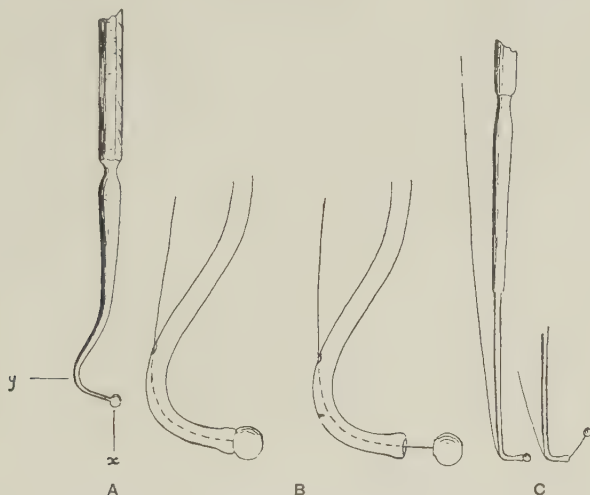


FIG. 40.—Showing how the cup-and-ball needles B and C were evolved from the dental stopping instrument, A (see text). The small needle, C, is the one used in tying the middle meningeal in gasserian operations.

plicity of the method. Using ordinary aneurysm needles, they tied the vessel correctly, but it was plain that a better tool would have made the task yet more simple. When the needle was threaded and then passed, the ligature lay back along the shaft, and was difficult to catch in the deep wound, while if the needle were passed unthreaded, it was not easy to expose and thread the terminal eye.

* Shown at the Section of Surgery, Royal Academy of Medicine in Ireland, April 27, 1923. Reprinted from the *Irish Journal of Medical Science*, 1924, Oct.

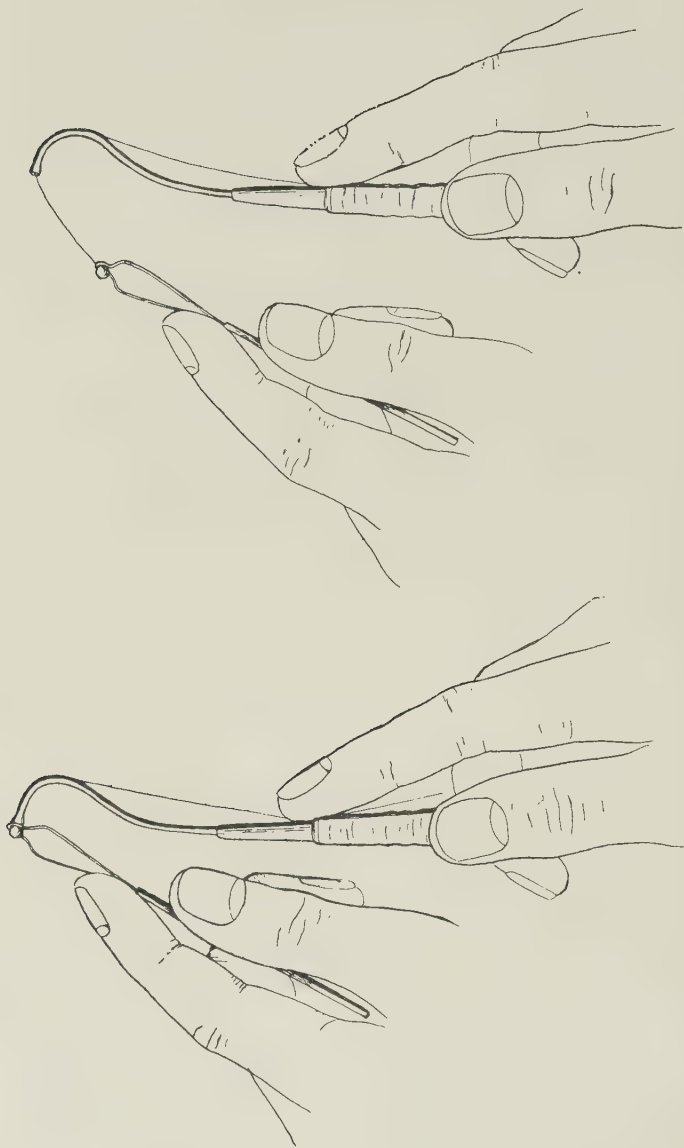


FIG. 41.—Showing how the wire loop retrieves the ball from the cupped end of the hollow needle.

On experiment, I found that an ordinary dental stopping instrument (*Fig. 40, A*) passed easily under the artery, and it occurred to me that if the smooth ball-tip (*x*) of the instrument were detached and pierced like a bead, and if the stem (*y*) were hollow, with a mouth wide enough to seat the ball, the ball could then be strung on a thread going through the stem. The thread, pulled taut, fixed the ball firmly to the cupped end of the stem, and the implement passed like an ordinary aneurysm needle under the vessel. It then remained merely to pick up the ball beyond the artery and thus retrieve the thread, which was done very simply under the guidance of vision or of touch by means of a fine hairpin bent into the shape shown in *Fig. 41*.

Keeping the thread taut, the ball was first made to enter the wide part of the loop, and was then caught at the constricted end; the thread was relaxed and the ball withdrawn.

I have had another and smaller model of this needle made for ligating the middle meningeal artery as a preliminary to operation on the gasserian ganglion or the cavernous sinus (*Fig. 40, C*). With modern technique, the aperture in the temporal fossa has a diameter of about 3 cm., while the distance of the artery from the surface of the zygoma is some 5 cm. Thus here too a deep vessel is tied through a small unyielding gap. Mr. A. A. McConnell and I have found that with my instrument ligation of the artery at the foramen spinosum becomes extremely simple.

When the ball is being strung on the thread, instead of knotting one end to secure the ball and passing the other through the hollow needle, it is better to slide the ball half-way along the thread, and then to pass the *two* ends through the tubular stem.

The first of these cup-and-ball needles were made for me by Mr. Edwin Haines, of Dublin. They are now made by Messrs. Down Bros., London.

A NEW METHOD OF RESECTING THE LEFT CERVICODORSAL GANGLION OF THE SYMPATHETIC IN ANGINA PECTORIS *

JONNESCO, in October, 1920, before the French Academy of Medicine, described a successful operation for painful anginal attacks associated with aortic disease.

The patient, a choir singer, age 38, was an alcoholic and syphilitic who used tobacco to excess. His heart and aorta were enlarged. His pulse showed irregularities not recorded by the electrocardiograph. Its rate was from 40 to 52. He had had four attacks of typical anginal pain in six months, and a fifth was observed in Jonnesco's wards. The precordial pain radiated into the left upper limb. A brief mercurial treatment had been without effect upon the attacks.

On April 2, 1916, Jonnesco successfully resected the patient's left middle and lowest cervical ganglia, together with the first ganglion of the thoracic series.

On leaving hospital, owing to invasion of Roumania by the Germans, he was not seen again until April 30, 1920, when he came to thank Jonnesco.

In spite of the hardships of living in invaded territory, he had never since the operation suffered from any return of angina, although admitting that he was still addicted to alcohol and tobacco. Examined by Professors Paulesco and Danielopoulo, it was found that his pulse-rate, which immediately after operation had increased to 56, and three days later to 68, was now 72 to 74, and without intermission. Radioscopy showed that the aorta was slightly dilated; its wall was still thickened and

* Read at the Section of Surgery, Royal Academy of Medicine in Ireland, Dec. 15, 1922.

was atheromatous. The face gave a false impression of asymmetry owing to the persisting signs of sympathetic paralysis which had followed the operation: the palpebral fissure was narrowed, the pupil contracted, and the eyeball sunken on the left side.

Such, in brief, is the history of Jonnesco's first case of sympathectomy for angina pectoris.

In a second communication to the French Academy he has since published a second success. In this case he not only resected the left cervicodorsal ganglion, but the middle and superior cervical ganglia as well, "in order to suppress every communication between the cardio-aortic plexus and the central nervous system".

While admitting that he succeeded in the first case with a less extensive sympathectomy, Jonnesco adds that the upper two cervical ganglia are easily removed.

Tuffier, speaking on this occasion in the discussion which followed, related how he had completely relieved a man of 50 with aortic sclerosis of painful crises, becoming more frequent and less endurable, by resection of the left cervicodorsal ganglion alone.

Thus, removal of the cervicodorsal ganglion of the left side appears to be sufficient to suppress anginal pain due to atheroma of the proximal aorta. In this connection it is to be remembered that the coronary arteries are branches of the ascending aorta, and that the plexus which accompanies each of them is a continuation of that related to their parent trunk.

The operation of sympathectomy was suggested to Jonnesco six cen years previously by François Franck, on the ground that the anginal syndrome might in certain cases be due to afferent impulses travelling up from the aorta by way of the cervicodorsal portion of the sympathetic chain. Impulses such as these from a viscus give rise to pain which is referred, not to the viscus concerned, but to somatic areas innervated by the segments of the spinal cord which receive the visceral impulse. This is

the explanation of the pains in the left arm and left chest, and, by irradiation, these may spread to the neck and to the opposite side of the body.

Franck further believed that death in anginal attacks might be due to vasoconstriction in the medulla oblongata—a view which must be considered in connection with the fact that the inferior cervical ganglia send thick branches which accompany the vertebral arteries, fusing when these vessels unite to form the basilar artery, and sending filaments along its branches to the pons and medulla. Franck claimed to have established that these were constrictor fibres to the vessels they accompany.

Jonnesco's object, then, in performing sympathectomy for anginal pain is twofold. First, he seeks to interrupt afferent impulses from the aorta which are responsible for the pain of the seizures, and possibly, too (though Jonnesco does not suggest it), for the 'grip' of the vagus upon the heart. Secondly, in removing the cervicodorsal ganglion he cuts the filaments which accompany the vertebral artery, which he believes carry constrictor impulses to the medullary vessels. Jonnesco describes his operation as very delicate but by no means difficult, and, again, he calls it '*simple et innocente*'.

Seen in the cadaver, however, there is nothing in the position or surroundings of the cervicodorsal ganglion to suggest the word 'innocent' except the difficulty of approach, and a brief consideration of the anterolateral route used by Jonnesco is essential.

The first dorsal and last cervical ganglia, which are often fused, are deeply placed at the thoracic inlet. The clavicle and the muscles attached to it combine to obstruct the approach, but other and more formidable obstacles intervene.

The cervicodorsal ganglion lies close to the head of the 1st rib in the little space between the scalenus anterior laterally and the longus colli medially. Through this space there ascend on the left side the common carotid artery and the subclavian artery—the vertebral branch of which passes inwards and

upwards behind the carotid, and is separated from that trunk by the inferior thyroid artery and thoracic duct. The vertebral vein, passing down to end in the subclavian, lies anterior to the vertebral artery, and near the first rib it receives the deep cervical vein from the back of the neck.

All these structures lie in planes which are anterior to the ganglion, and thus help to screen it from the surgeon who uses the anterior approach. The veins are an especial danger as they are easily wounded.

The cephalic end of the ganglion touches the back of the vertebral artery (*see Fig. 42*), and while the junction of the cervical and dorsal portions of the ganglion is often marked by a constriction, the demarcation of these moieties is emphasized, as a rule, by an abrupt change in direction of the long axis of the thoracic portion, which descends backwards and *outwards* into the thorax, forming almost a right angle with the cervical moiety. This frequent disposition of the ganglion should be remembered by anyone who attempts the anterolateral approach, if he would avoid futile groping in a perilous field.

My interest in a posterior approach was first aroused by a paper read in 1920 by Sir William Wheeler, when he described a case in which he had resected part of the 1st thoracic rib by an anterolateral route in a case of compression neuritis of the lowest brachial trunk. During the discussion which followed I expressed the opinion that the simplest approach to the rib might be from behind, and since then repeated experiment upon the cadaver has confirmed my belief.

The cervicodorsal ganglion of the sympathetic lies upon the front of the joint between the head of the 1st rib and the body of the 1st dorsal vertebra, and the transverse process of this vertebra lies behind the head of the rib. It was therefore not unnatural to consider the possibilities of reaching the ganglion by resecting these two bony structures—that is to say, by a costo-transversectomy at the level of the 1st rib.

The vertebral end of the 1st rib is in the fork formed by the

two great contributions which the 8th cervical and 1st dorsal nerves send to the brachial plexus. The safe removal of the rib from their proximity presents no difficulty, but when it has been removed, the ganglion must be approached, as it were, through the fork of a catapult of which the handle is the lowest trunk of the brachial plexus. Though it was possible to remove the ganglion through this fork, I was not satisfied with the well-defined but narrow access which it gave. The approach I now describe is far less cramped; the ganglion can be found at once, and can be removed with a minimum of risk to surrounding structures.

The Second Rib.—Robbed of our scapulæ, we are hunch-backed; the normal kyphosis of the upper dorsal spine is masked by the shoulder-blades: the vertebral end of the 2nd rib thus reaches a plane which is dorsal to that of the 1st. The transverse process, too, which articulates with the 2nd rib extends, not only outwards and back, but *upwards* towards the skull, and so lies level with the head of the 1st rib.

If it is remembered that the cervicodorsal ganglion is close in front of the 1st costal head, it will be clear that a horizontal section through the tip of the second transverse process will at least graze the head of the 1st rib and the cervicodorsal ganglion of the sympathetic.

The 2nd rib and dorsal transverse process, then, are the keys to the position.

ANATOMY OF THE POSTERIOR ROUTE.

Before describing the technique of operation, brief reference must be made to certain anatomical details.

Anatomy of the Ganglion.—The main cord of the sympathetic chain in the neck goes from the highest to the middle cervical ganglion. The latter lies at the level where the inferior artery of the thyroid arches in towards the gland. From there the cord drops down to the space between the vertebral bodies and the anterior scalene muscle. As it enters this space it passes

to the inner side of the vertebral artery, winds to the back of that vessel, and joins the cephalic end of the cervicodorsal ganglion without losing contact with the artery. The caudal part of the ganglion, however, is separated from the vertebral and subclavian vessels by an interval which is occupied by the apex of the lung covered by the pleural dome, for the subclavian grooves the front of the lung *below* the apex (*Fig. 42*). I shall presently show how advantage may be taken of this interval for the safe separation of the ganglion from the vertebral artery.

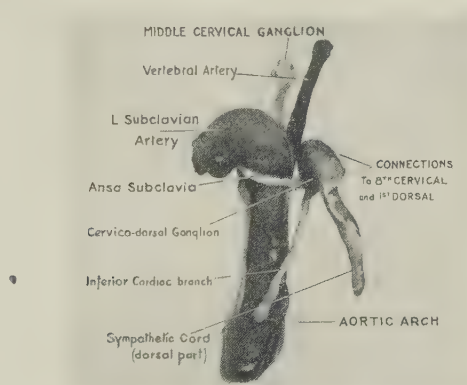


FIG. 42.—The left cervicodorsal ganglion seen from the left and slightly from behind, showing its connections, and the strategic interval between its caudal part and the back of the subclavian and vertebral arteries. This interval is filled by the pleural dome. (*From a photograph of a wax model made by Miss E. Barnes, of the National Museum, Dublin.*)

The ganglion is, of course, anchored by its branches (*Fig. 42*). Above and below, the sympathetic cord unites it to the middle cervical and 2nd dorsal ganglia respectively. Behind, it is bound by stout communications to the 8th cervical and 1st dorsal nerves. In front the loop of Vieussens, which embraces the subclavian artery, connects this ganglion with the middle cervical. From its inner side descends the inferior cardiac nerve, which often springs from the ganglion by several roots. From the cephalic end, too, there arise strong branches which stream up the vertebral artery.

In removing the ganglion from behind, the sole connection which is immediately visible is that passing to the second ganglion of the dorsal series, and one is tempted to divide this stout, flat cord and to pull out the ganglion by the tail. The other connections, however, though slender, are remarkably tough, and a pull of this kind in the cadaver will often bring away a segment of the vertebral artery. Each connection must be carefully divided in the sequence described below with the technique of operation.

The Muscular Planes.—The part of the 2nd left rib which is removed lies between the scapula and the vertebral spines :

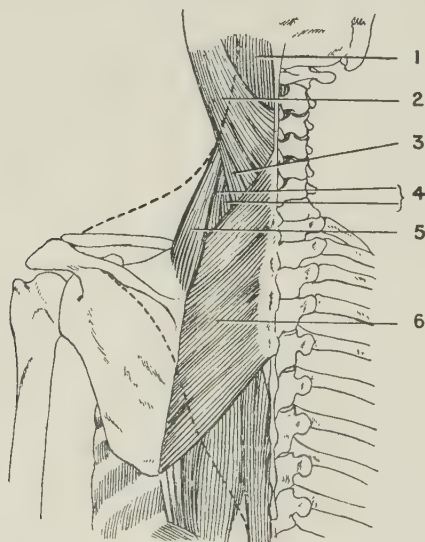


FIG. 43.—Showing the muscles that lie deep to the trapezius, which is indicated by the dotted line. (1) Complexus. (2) Splenius capitis. (3) Splenius cervicis. (4) Cervical extensions of erector spinæ. (5) Levator scapulæ. (6) Rhomboids.

it is concealed by muscles which anchor the scapula to the vertebræ. The trapezius is spread over the rhomboids which cover the upper serratus posterior. Division of these muscles allows the surgeon to widen the space between the scapula and the spine, and it is essential that the transverse width of the wound should be as great as possible. Deep to these muscles

of the shoulder girdle, the splenius spreads upwards from the dorsal spines, and lateral to the splenius are the cervical extensions of the erector spinæ (*Fig. 43*).

The Second Rib must be accurately identified. It is not difficult to mistake it for the 1st, and thus in error to remove the 3rd rib. The 2nd rib and transverse process viewed from behind lie dorsal to the 1st, and the body of the 1st rib slopes forwards from the costotransverse articulation; it is difficult to palpate. When, however, the trapezius and the other muscles passing to the scapula have been divided and retracted, the 1st rib can be felt by hooking the finger deeply down along the neck. The 1st dorsal transverse process is a good landmark (*Fig. 44*): it lies at the level of the 7th cervical spine three finger-breadths from the middle line. It is the first transverse process to project beyond the edge of the splenius. Here its tip is felt but not seen, being covered by two cervical extensions of the erector spinæ (the iliocostalis cervicis and the longissimus cervicis). Reckoning from this landmark, the surgeon finds the 2nd transverse process and the 2nd rib. For additional security the 2nd rib should be localized by radiography before operation, and the radiologist should be asked to examine the thoracic inlet for accessory cervical or rudimentary thoracic ribs, which might confuse the surgeon approaching them from behind.

A good headlight should be used, but in the cadaver I have repeatedly performed the operation without artificial

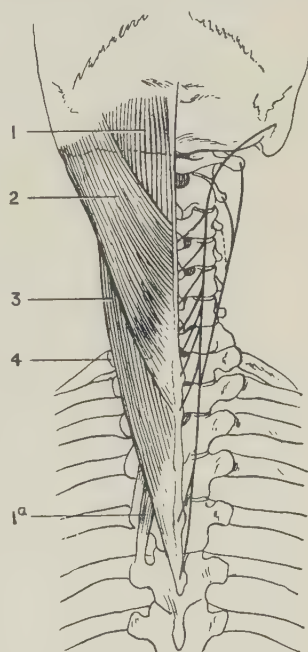


FIG. 44.—The 1st dorsal transverse process is the first which projects beyond the edge of the splenius. It forms a deep landmark for identifying the 2nd rib. (1) Complexus. (2) Splenius capitis. (3) Splenius cervicis. (4) 1st dorsal transverse process. (1a) Complexus.

illumination. The patient should lie prone with the left shoulder clear of the table, and the left upper limb hanging vertical (*Fig. 45*). Make the upper dorsal region as kyphotic as possible. This gives the space between the scapula and the vertebral column its maximal width.

Find the 7th cervical spine. Mark (*a*) a point four finger-breadths above it and one finger-breadth to the *right* of the middle line; (*b*) A similar point six finger-breadths below the 7th spine; and (*c*) A point over the middle of the spine of the left scapula. Join these three points by the incision shown in *Fig. 45* carried down to the sheath of the trapezius muscle.

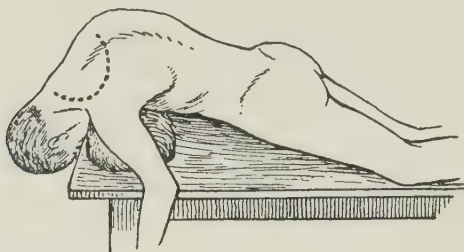


FIG. 45.—Showing skin incision and position securing maximum abduction of the left scapula.

Raise the flap of skin and subcutaneous tissue thus outlined, and turn it over to the *right* of the middle line.

With a vertical cut, one finger-breadth to the left of the vertebral spines, divide the origins of (*a*) the trapezius, (*b*) the rhomboids, and (*c*) the serratus posterior superior. Do this first at the middle of the wound where the silvery tendon of the serratus indicates the depth reached. Extend this incision throughout the entire length of the wound. Retract the divided muscles outwards. The pointed caudal end of the fleshy splenius is now exposed. At the level of the 7th cervical spine and three finger-breadths from the middle line, find the tip of the 1st left dorsal transverse process, remembering that it is the 1st which projects beyond the edge of the splenius. Find the 2nd left rib.

Clear the transverse process of the 2nd dorsal vertebra as far as the lamina. Clear at least three inches of the 2nd rib. Divide the transverse process at its root and remove it.

Divide the rib as far as the wound will permit from the costotransverse articulation.

Raise the proximal cut end of the rib. With the finger push the pleura away from its head and neck. Rotate the rib segment and divide its attachments. The sympathetic cord is now seen close to the vertebral body, lying on the pleura like a tape.

Very gently push the intact pleural dome downwards and outwards from the vertebræ. A small strand will now be found holding the pleura to the neck of the 1st rib. This strand is a

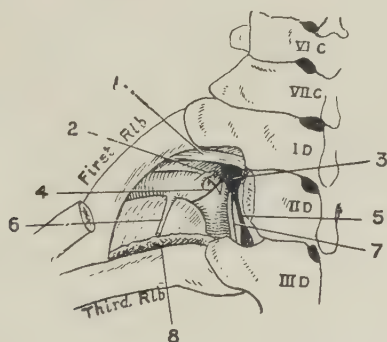


FIG. 46.—Caudal part of the left cervicodorsal ganglion (3) seen from behind after removal of the 2nd dorsal transverse process and part of the 2nd rib. The pleural dome has been retracted down, exposing the 1st stage of the left subclavian artery. (1) 1st dorsal nerve. (2) Costocervical trunk. (3) Cervicodorsal ganglion of sympathetic concealing vertebral artery. (4) Ansa subclavia crossing subclavian artery. (5) Sympathetic cord passing to 2nd dorsal ganglion. (6) Internal mammary artery. (7) Inferior cardiac branch of sympathetic. (8) Pleural dome retracted downwards.

twig from the superior intercostal branch of the costocervical trunk: divide and tie it. The pleural dome can then be freely depressed until the subclavian artery is seen (*Fig. 46*). A broad retractor, polished to reflect light, keeps the pleural dome out of the field.

Pick up the sympathetic cord and divide it between the cervicodorsal and the 2nd dorsal ganglion. Divide the

communications between the back of the ganglion and the 8th cervical and 1st dorsal nerves.

The right index finger is next passed, nail down, into the strategic interval between the ventral face of the ganglion and the back of the vertebral artery (*see Fig. 42*), and by gentle traction on the sympathetic cord the ganglion is coaxed over the pulp of the finger in the direction of the patient's feet: at the same time the finger-tip works it loose from the artery. As this is done the branches which pass to the artery come into view and are divided. A little further coaxing, and the cord which passes up to the middle cervical ganglion is seen and cut. Finally, the resection of the ganglion is completed by dividing the inferior cardiac nerve.

Reconstruction of the anatomical planes is simple when the head and neck are brought once more into line with the trunk, and when the left upper limb is replaced upon the table.

In conclusion, it may be observed that the operation of ganglionectomy by the posterior route has certain analogies with that for resecting the gasserian ganglion, and a comparison of the two procedures shows a balance of simplicity in favour of the first.

In gasserian ganglionectomy the approach to the skull is through the temporal muscle; in resection of the cervicodorsal ganglion the 2nd rib is found deep to the vertebroscapular group. The brain clothed by its meninges is retracted upwards; the lung ensheathed by pleura is retracted down. The middle meningeal and superior thoracic arteries respectively are dealt with. But while the surgeon in the cerebral operation must find his way by deep and often difficult dissection to a ganglion hidden in Meckel's cave, the cervicodorsal ganglion lies naked within easy reach of the finger, and the vertebral artery beyond is less dangerously placed than the cavernous sinus.

PITUITARY SURGERY BY A NEW METHOD*

"We have sacrificed opportunities of progress in the anatomy, physiology, and surgery of the brain by too ready acquiescence in the assumption that we must remain dependent on the visual sense for every species of intracranial operation."—H. CLARKE.

"They draw out the brain through the nostrils; not the whole, but a part only."—HERODOTUS, ii, 86.

THE pituitary gland occupies a more impregnable position than most of the structures attacked by surgeons. Like other impregnable positions, it has been taken repeatedly; but it has not been taken easily. The fossa in which it lies is invested above by the optic chiasma, on either side by the cavernous sinus surrounding the internal carotid artery and including the 3rd, 4th, 6th, and parts of the 5th cranial nerves. Behind it is the brain stem.

No method of approach has yet been described which is at once safe and accurately controlled, but many methods of reaching the gland have been devised. Three must be considered:—

1. *The orbitofrontal route* of McArthur and Frazier.
2. *The frontotemporal route*, first suggested by Krause, and used by Heuer and Adson.
3. *The transphenoidal route*, with submucous resection of the nasal septum, elaborated by Cushing.

By all these methods the surgeon relies upon direct vision, and what he sees lies at the bottom of a deep recess. He has no accurate means of controlling the exact position of the end of his instrument in a distant and perilous field; the mental strain in consequence is not easy to exaggerate.

* First described in the *Dublin Journal of Medical Science*, April, 1921. It formed the subject of a paper read at the Société Internationale de Chirurgie, London, 1923.

Frazier's *orbitofrontal route* involves turning down an osteoplastic flap of the frontal bone, removing the roof of the orbit, and retracting the orbital contents downwards, and the frontal lobe upwards. Division of the dura gives the operator access to the tumour, which is still screened from him at the apex of the deep recess by the optic nerve and the carotid artery.

In the *frontotemporal approach* used by Adson, an osteoplastic flap is made in the temporal fossa, the dura is opened, and the frontal lobe raised. The edge of the lesser wing of the sphenoid is used as a guide to the optic nerve, and thus to the pituitary tumour.

With Cushing's *transphenoidal approach* by the nasal route, the surgeon is working at the bottom of a long, narrow tunnel, which he must keep illuminated.

He first resects the septum submucously, up to the sphenoidal sinus; so far, so good. He is now faced with the problem of the sphenoidal sinus. This sinus may be absent, for the sphenoidal body may be solid; and the surgeon is then without a guide to the position of the pituitary fossa, which normally bulges into the sinus.

Again, the sinus may be divided by a septum into anterior and posterior compartments, and the surgeon may mistake this septum for the pituitary floor. Or, yet again, the sinus may extend so far backwards, beneath the pituitary fossa, that it may lead the operator to attack the floor of the posterior cranial fossa, and so to endanger the brain stem. The penalties for deviation from the middle line in this route are formidable.

THE CHOICE OF ROUTE.

With regard to the choice of route, it is significant that Cushing, whose operations upon the pituitary outnumber the aggregate of those performed by all other surgeons who have ever attacked this region, should have performed the great majority of his operations by the nasal route. Up to 1916 he had used it 106 times with a mortality of under 10 per cent. In

his Weir-Mitchell Lecture for 1914, Cushing states that "the cases for which a frontal operation is indicated cannot compare, either in number, or on the ground of risk or of promised improvement, with those in which a transphenoidal operation is suitable".

Much, however, has been written in disparagement of the transphenoidal approach, for many pituitary tumours spread upwards, and it is claimed that only a partial removal of these can be effected by the transphenoidal method.*

Mr. Adams A. McConnell and I, using the illuminated retractors devised by Frazier, in 1921 tried upon the cadaver all the intradural routes which have been described. We were struck by the inaccurate conception which published illustrations of these routes give of the depth and limitations of the operative field. Heuer and Adson have certainly achieved brilliant results by the intradural route. But it is to be noted that the mortality with this approach is more than double that of Cushing's transphenoidal method. The anatomy of the region makes it difficult to believe that complete removal of a pituitary tumour can be anything but an exceptional possibility. Excellent results, both in respect of vision, relief of pressure, headache, and dyspituitarism, have attended a partial resection of the gland, and these facts, taken in conjunction with the difficulty and danger of the intradural approaches, even in the hands of specialists in cranial surgery, tend to emphasize the possibilities of the transphenoidal route.

I have already alluded to the difficulties and dangers which attend its use. If it is to command a wider confidence than it has yet attained, if it is to become as safe in the hands of the general surgeon as in the hands of Cushing, these difficulties and dangers must be eliminated. Their elimination, as I shall

* This undoubtedly is often true, but since 1920 there has been a widespread tendency to revert to the transphenoidal method. Thus C. H. Frazier, whose name is associated with the orbitofrontal route, has recently published a series of eighteen consecutive transphenoidal hypophysectomies.—(*Arch. of Surg.*, 1924, viii, 39.)

presently show, can be largely effected by the use of radiography, and of a special instrument (*Fig. 47*), which can be trained like a gun on the pituitary gland.

Radiography, of course, plays an indispensable part in pituitary surgery. It is essential, not only for diagnosis, but, if the transphenoidal route is contemplated, it gives invaluable information with regard to the variable relations of the pituitary fossa and the sphenoidal sinus. It can, however, do much

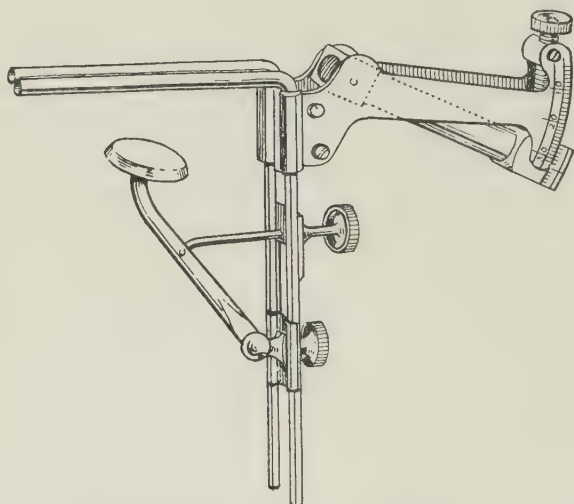


FIG. 47.—Pituitary 'gun' with which the gland can be attacked under radiographic control. (For details see *Fig. 48*.)

more than this. It can, by the use of the instrument which I have devised, guide the surgeon infallibly to the pituitary fossa. The method occurred to me in August, 1920, after reading that de Martel had, before operation, had the pituitary fossa localized, as if it were a projectile. His method, however, was not further described, and, unfortunately, the beautiful procedure, perfected by the French, of direct radioscopic control during the actual operation of removing a projectile, is not available for removing the pituitary; the definition of the fossa and the sphenoidal sinus upon the fluorescent screen is far too vague to give the operator much aid or security. It appeared to me then that,

as continuous radiosopic control was out of the question, an instrument could be devised which would admit of sufficient intermittent control, by the taking of successive radiographic negatives, to give an accurate means of access to the gland. By its aid capillary tubes containing radium emanation can be inserted directly into the tumour itself, or the tumour may be bitten away by means of a crocodile forceps. Briefly, any manipulation is available which can be carried out through a tube, and instruments resembling those designed for use with the urethroscope, or cystoscope, may be employed for this purpose.*

The two chief requirements of the instrument are : (1) Absolute stability ; and (2) The median position must be exact—the long axis of the instrument must be accurately in the sagittal plane.

The instrument (*Fig. 48*) consists of the following parts : Two intranasal bars lie one on either side of the nasal septum. These bars bend vertically downwards in front of the lips and support a pivoted rod with a terminal cap which enters the mouth. This cap presses against the hard palate, when a screw approximates the rod to the vertical bars. This part of the instrument is vital to its success, for upon it depends its capacity of maintaining an absolutely fixed position, and I am indebted for this simple and effective device to my wife, Dr. Dorothy Milne Henry. To the vertical rods are attached two plates, between which is pivoted a tube, which can be inclined at an angle to the horizontal by means of a screw. The squared end of this tube carries a vernier, which moves over a scale attached to the plates and enables the inclination of the tube to be

* When this paper was first published in 1921 I suggested the possibility (*loc. cit.*) of using the high-frequency current to destroy pituitary tumours by means of an electrode directed through the instrument. In the absence of experimental facilities the suggestion was omitted when the paper was revised. It has a new interest in this connection since the publication of Prof. Cushing's MacEwen Lecture on meningiomas and their removal by electro-surgery. (*Lancet* June 25, 1927.)

accurately adjusted to one-quarter of a degree. After the nasal septum has been resected submucously to afford a path to the face of the sphenoidal sinus, the instrument is fixed in position with its long axis in the sagittal plane. This position of the axis is verified by an anteroposterior radiogram, taken by a method for which I am indebted to Dr. T. Garrett Hardman, radiologist to the Richmond Hospital, Dublin. A lead pellet is fixed with plaster to the skin over the nasion and another over the inion :

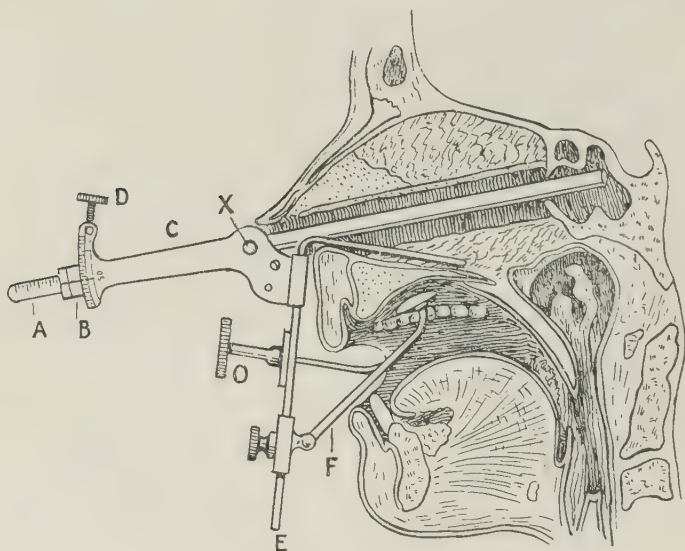


FIG. 48.—The mucous membrane is removed from the left side of the septum to show the part resected and the trephine in position. A, Graduated handle of trephine projecting from the square end of the tube B, which carries a vernier. This travels on the scale marked in degrees on the plate C. The tube B is pivoted at X between this plate and its fellow. D, Screw for regulating the inclination of tube B. E, one of the two bars which enter the nasal fossæ. These bars support F, the intrabuccal rod and cap. By turning the screw O, the instrument is stabilized.

the patient's head is moved until the shadows of the pellets are concentric, and the radiogram is taken with the head in this position. If the long axis of the instrument is in the sagittal plane it will point to the fused shadow of the pellets.

A trephine with an obturator is then introduced through the tube of the instrument along the submucous path to the

face of the sphenoidal sinus. The trephine and all instruments used through the inclined tube are graduated in such a way that the precise distance they project beyond the pivot of the tube can be read upon their handles. An adjustable collar allows each to be introduced as far as is required, and no farther.

Preliminary Orientation.—The approximate inclination of the tube needed to aim at the floor of the pituitary fossa through

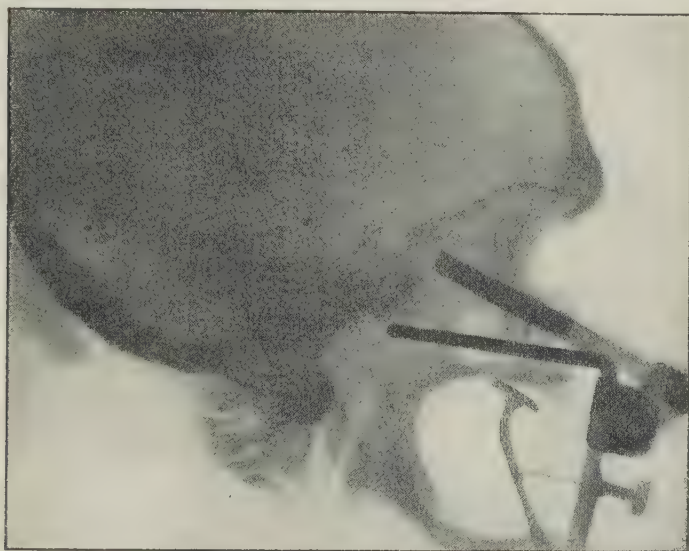


FIG. 49.—Profile radiogram showing instrument in position, with trephine aiming at the pituitary.

the sphenoidal sinus is determined by a preliminary radiogram, taken at any time before the operation with the instrument in position. When the trephine has been passed up to the face of the sphenoidal sinus, its direction is verified by another radiogram, taken in profile (*Fig. 49*), after securing the horizontal position of the head by screening it with a lead pellet in each auditory meatus and making the two shadows fuse. (The pellets and pins may be so chosen that their shadows, when superposed, not only are concentric, but coincide.)

Verification of Aim.—If the inclination of the tube is incorrect, it can be easily and rapidly rectified by means of the device shown in *Fig. 50*. The two arms are set at the angle recorded on the scale of the instrument. The graduated arm is advanced beyond the pivot of the circular frame, to a distance equal to that of the teeth of the trephine from the pivot of the tube. The arm is then laid upon the negative of the profile radiogram so that its point and long axis coincide on the plate with corresponding parts of the trephine's shadow (*Fig. 51*). The quadrant is held fixed by

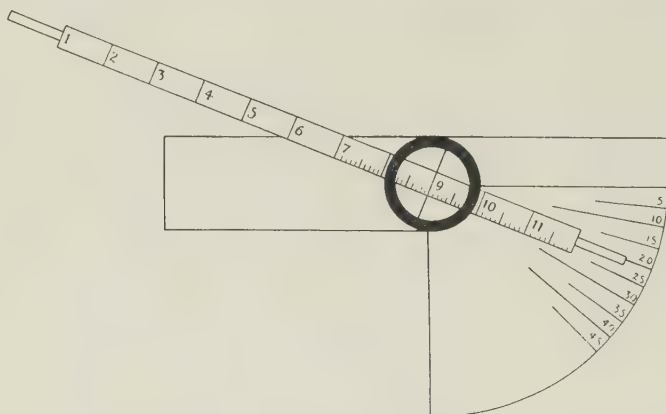


FIG. 50.—Finder for correcting aim of trephine and for getting the range from the radiogram. The graduated arm slides through the round frame which is pivoted at the centre of the quadrant.

the observer, and the inclination of the graduated arm is altered until its point, when advanced, will strike the outline of the pituitary floor upon the negative. The correct angle of inclination and the distance through which the trephine must be advanced can thus be read directly, after two simple movements.

The correspondence between the measurements on the film and the actual distance of the trephine from the pituitary floor is very close at the centre of the field. Thus with the X-ray apparatus used in this work, and with heads of average transverse diameter, I found that 11 mm. on the negative corresponded to an actual distance of 10 mm.

Confirmatory Radiogram. — The sphenoidal sinus is then penetrated, and the trephine advanced through the required distance, which has been determined by the radiogram, to the floor of the fossa. Its position here can once more be verified by a third radiogram.

The fossa is then penetrated, and the tumour may be nibbled away with crocodile forceps, or radium may be implanted into it.

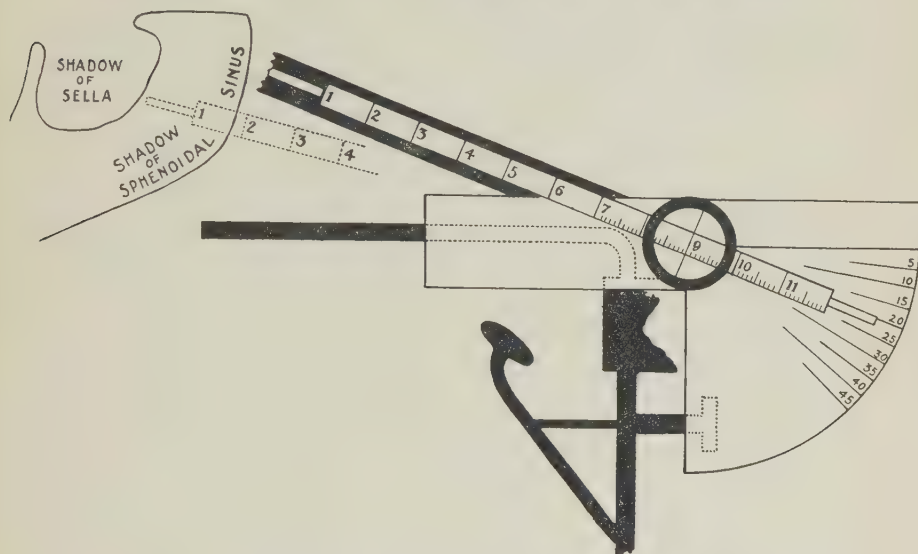


FIG. 51.—Showing the finder (white) superposed on the shadow of a mis-directed trephine (black). If the film shows that the trephine is incorrectly aimed, (a) the range-finder is set at the same incorrect angle as the trephine; (b) The graduated arm is advanced through the frame to exactly the same distance as the trephine has been advanced beyond the pivot of the tube. The arm of the finder is then laid on the shadow of the trephine, and the quadrant is steadied on the film. Two movements of the graduated arm bring it into the position of the dotted outline, giving the correct aim and range.

THE OPERATION.

With regard to the actual technique of operation the following steps may be described:—

1. The operation is performed in the X-ray room. A preliminary radiogram, with the instrument in position, may with advantage be taken several days before the operation. This can be done using cocaine to anæsthetize the nasal floor and the

palate. This radiogram will give indications of the approximate elevation required, and the distance from the pivot of the tube to the sphenoidal sinus and the pituitary floor. Rectal etherization, given by Boyd's safe modification of Gwathmey's method, is the anæsthesia of choice.

2. This allows the patient to be placed in the seated posture with the head thrown back and supported.

3. Submucous resection of the septum.

4. The instrument is adjusted in the nose and mouth as in *Fig. 48*, and its tube is aimed at the pituitary through the sphenoidal sinus. The approximate inclination has been estimated from the preliminary radiogram.

I have already described the remaining stages of the operation, which include verification of the position of the trephine by anteroposterior and profile views, which enable the pituitary fossa to be penetrated with precision in the middle line.

My first experience with the instrument in the living, after a year's experimental work on the cadaver, was not, however, in a case of pituitary disease, but in one of sphenoidal sinusitis, in which it gave excellent results.*

I have since used it in two operations upon a case of hypopituitarism with irregular hemianopia, followed by blindness, in which radiography appeared to show a greatly enlarged sella. At the first operation a part of the pituitary was removed easily, and without any incident except the occurrence of a polyuria of 5 litres daily for three days. Six weeks later, as the blindness was unrelieved, a second operation was performed, and a second moiety of gland was removed. This intervention was followed by death in eight hours.

Autopsy revealed the fact that the hypopituitarism was due to an occlusion of the aqueduct of Sylvius causing hydro-

* In this and in the second operation the resection of the nasal septum was done by my former colleague, Dr. Stafford Johnson, who also successfully performed what was by far the most difficult part of the third operation, namely, the separation, after six weeks, of the two cicatrized layers of the septal mucosa.

cephalus, and giving rise to a rarefaction of the bones, which, in the radiograph, had simulated a deep excavation of the sella. Only a very small fragment of pituitary substance remained. Death was due to diffuse choroidal hæmorrhage caused by the sudden relief of pressure following a small tear in the third ventricle which had bulged down into the almost empty sella. This tear gave rise to a gush of cerebrospinal fluid which, at the time, was thought to come from a cyst. I should add that these operations were performed before ventriculography became our common practice.

The point which I wish to emphasize is, that at the first operation the greater part of a small compressed gland, offering an exceptionally small mark for the instrument, was removed without ill result. Failure in this case was due to the diagnosis, and not to the instrument. The opening made by it into the sella was as precisely centred as if drilled from within under direct vision.

The design of the instrument was most admirably carried out for me by Mr. Edwin Haines, of Dublin. I am much indebted to him for his instant comprehension of detail in the problem in hand, and for giving its solution form and substance.

A table of the actual procedure employed at the first operation on the pituitary in which my instrument was used is appended.

Stages in the Operation on the Pituitary Gland, after the Resection of the Nasal Septum.—Prepare the patient, with lead pellets attached to the head: (1) Anteroposterior (on the nasion andinion); (2) Lateral (in ears).

Introduce the instrument into the nose and mouth, and make it stable. Insert the trephine and obturator.

Note: The teeth of the trephine were clogged with wax to avoid catching in the nasal mucosa.

Radiogram.—Take an anteroposterior radiogram to verify the sagittal position of the trephine.

With the trephine, bore three holes into the sphenoidal sinus, one above the other, thus:—

Set the trephine at 9.5 cm., i.e., so that its teeth can be advanced 9.5 cm. from the pivot of the tube, and no farther. (This distance was calculated from a preliminary radiogram.)

The trephine is to be inclined at the following angles: 1st, 19° (i.e., the angle estimated by a preliminary radiogram); 2nd, 21°; 3rd, 17°. (These inclinations allowed the trephine to cut a vertical slot as wide as its own diameter in the face of the sphenoidal sinus.)

Withdraw and clean the trephine, and reintroduce it with the obturator and wax. Advance the trephine gently at 19°, through $\frac{1}{2}$ cm. (i.e., with trephine set at 10 cm.).

Radiogram.—Take a profile screen with ear pellets to verify horizontal position of head. Take a profile radiogram.

If necessary* calculate with range-finder: (1) The change in the angle required to aim at the pituitary; (2) The distance to advance the trephine in order to reach it. Set the instrument to these two readings. Advance the trephine through the sellar floor.

Withdraw the trephine and remove the débris.

Reintroduce the trephine with the obturator wax, after shortening the trephine 1 cm. Withdraw the obturator. Introduce alligator forceps through the trephine with handles up, adjusting the collar on the handles so that their jaws can project 1.5 cm. beyond the end of the trephine.

Remove part of the gland.

Note: The time occupied in the above procedure, after resection of the septum, was seventy minutes. This sufficed for the taking of the radiograms and the operative steps.

* No correction was required at the first operation.

20 -

LHW-Med-102

G-M author

1st ed., Amer. issue

